特別講演

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The Development of the German Steel Industry during the Past 25 Years*

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1. Survey of the development

The development of the German steel industry during the past 25 years can be divided into three major periods.

In **period I,** from the end of World War II to 1952 (Fig. 1), the German steel industry was controlled by the Allied occupation forces. Owing to war damage, the demand for steel throughout Europe was enormous. And yet, as a result of the long-term Allied plan. German crude steel production was curbed to some 6 million tons per year. That amounted to approximately 30% of the 1937 production. Any capacity exceeding this figure, provided it was not destroyed during the war or lost as a result of cession of territories, was to be dismantled. The bast facilities were selected for dismantling.

The objective of these measures was to curb the competitiveness of the German steel industry. This also included the regulations of the Allied occupation forces on decartelization of the steel corporations. Organically grown companies were split up into a great number of smaller, independent units. Figure 2 furnishes an example of the dismemberment of former Vereinigte Stahlwerke which, founded in 1926, was capable of producing as much as 7 million tons by that time.

At the end of decartelization, from a couple of efficient big corporations in Germany there had emerged a total of 26 independent companies which competed with each other in their investments and their products. The consequences were misdirected investments and developments. In addition, eventual mergers of the companies into larger units were impaired through difficulties arising from personnel and technical problems because nobody tends to give up an independence which he has just won.

August Thyssen-Hütte can be cited as an example (Fig. 3) to demonstrate the kind of difficulties which had to be overcome by each of the companies. It had been hit particularly badly both by war damages and dismantling. Only the trunk was left of a previously well rounded company having a crude steel production of 4 million tons per year and a balanced material flow. Economical production was no longer possible. A similar situation prevailed in the rest of the German steel mills.

The German crude steel production, which was at first limited to some 6 million tons per year, was increased to some 11 million tons later on. All output limitations were finally removed in 1952 when the European Coal and Steel Community was founded. This enabled the German Federal Republic to act as a somewhat equal partner within the European Community. It was not until this signal appeared that the production capacities were really rebuilt and extended in response to a more sophisticated steel market.

This initiated **period II** of the development, which lasted from 1952 to about 1960 (Fig. 1). In the German Federal Republic, it was characterised by a marked upswing in the overall economic situation associated with a high demand for steel. This upswing was described the world over as the "German economic miracle".

Crude steel production increased from 15.8 million tons in 1952 to 34·1 million tons in 1960. In 1959, the Saar area with its crude steel production of 3·6 million tons was reintegrated into the GermanFederal Republic.

During the period 1957 to 1960, successful attempts were made to remove the restrictions imposed so far on working hours on Sundays in steelmaking and first-heat rolling shops. A problem which is completely unknown in Japan.

The first wave of investments extended from 1952 to 1955. It was triggered by an investment assistance law which allowed up to 30—50% of

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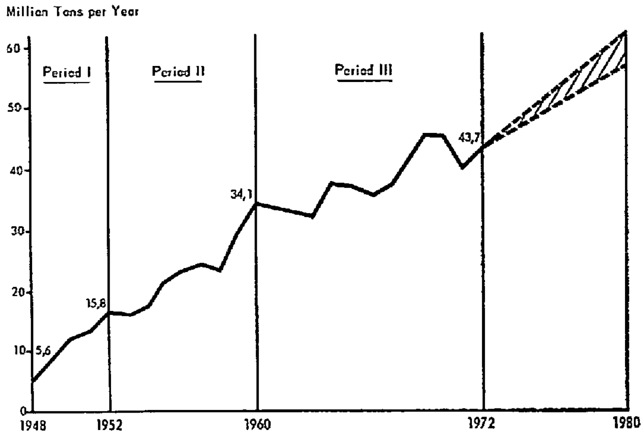

Fig. 1. Crude steel production in the federal Republic of Germany.

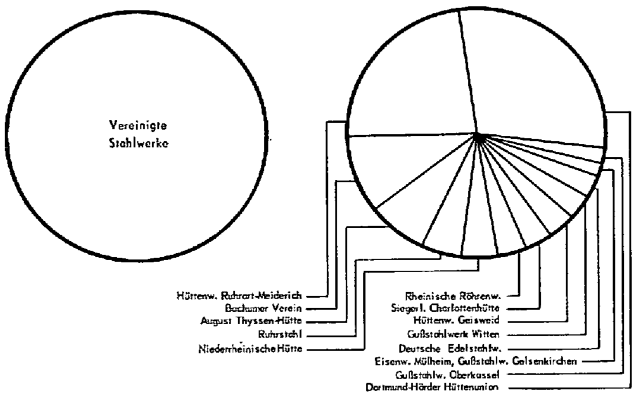

Fig. 2. Successor companies in 1953 of Vereinigte Stahlwerke.

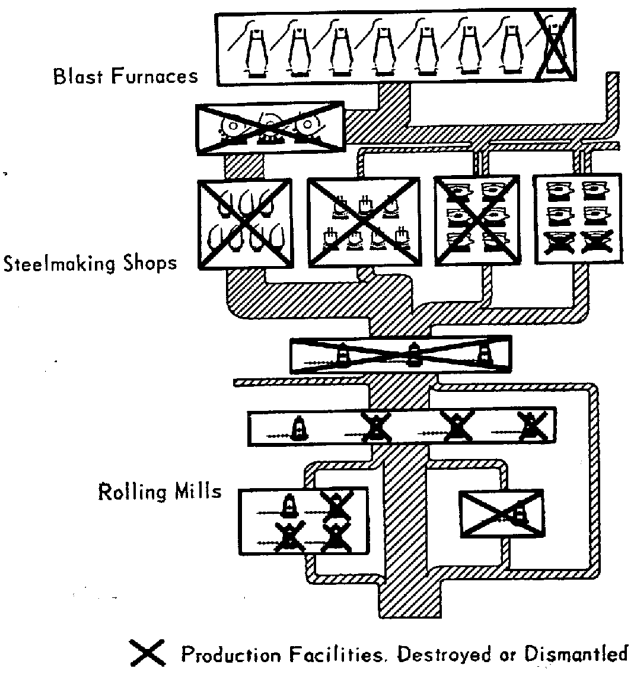

Fig. 3. Pre-war structure of August Thyssen-Hütte and conditions existing after war destruction and post-war dismantling.

special depreciation on real investments in the steel industry. Retrospectively, this first investment drive came a little too early from a technical point of view. The breakthrough of modern technology, such as the basic oxygen steelmaking process, did not occur until later. Therefore, the companies still made investments in facilities of the conventional type, such as basic Bessemer converters and openhearth furnaces. But, the possibility of high depreciation allowed the companies to follow the technical development and to replace these facilities by modern, large units, especially in the sixties. It should be noted, however, that the fatal interference with the structure of the German steel industry during the first postwar years caused permanent damage. Too many independent companies were created, partially with an unsatisfactory flow of materials. This also implied the renewed utilization of unfavourable locations. The rapid economic development of phase II largely concealed this situation and the necessity of merging into a few rational companies the great number of enterprises which had res ulted from decartelization.

During **period III** (Fig. 1) crude steel production increased from 34·1 million tons in 1960 to 43·7 million tons in 1972. The development showed three cyclical setbacks. By 1980, the increase in German steel production is expected to be as depicted in Fig. 1.

During this period, competition became keener worldwide. The German steel industry reacted to it by building larger production untis, by coordinating marketing activities, and by balancing and rationalizing production programs. In principle, this did not cause any change in the positive German attitude towards a liberalised European steel market.

In 1972, seven companies accounted for approximately 80% of the crude steel produced in the German Federal Republic (Fig. 4). This meant that, from an organizational point of view, an output was attained such as existed before World War II since about 90% of the crude steel was produced by only six companies as early as 1938.

In 1967, with a view to improving the earnings, most of the steel companies merged to form four organizations (Walzstahlkontore) handling the sale of rolled steel products made by the member companies. These sales organizations were competing both with each other and with the rest of the sales offices in the EEC. When their agreements expired in 1971, four rationalization groups were formed with a similar objective but independent sales activity through each of the member companies.

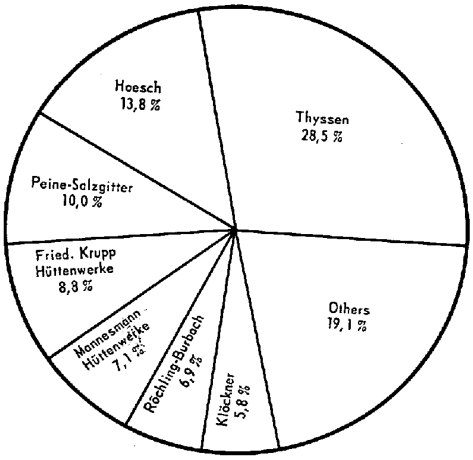

Fig. 4. Percentages of crude steel production in the Federal Republic of Germany in 1972.

Period III is characterized on the technical side by the large-scale adoption of modern processes. An example of this trend is the changeover from the basic Bessemer process to the basic oxygen steelmaking process. Small and obsolete facilities were shut down and replaced by units of economical size. Following this reshuffle and rationalization, a total of 66 blast furnaces, 77 basic Bessemer converters, and 133 openhearth furnaces have been shut down since 1955.

During the past 7 years alone, a total of 91 rolling mills were closed down. Some DM 29 billion was invested during the past 20 years in new production facilities, of which 34% was spent on blast furnaces and steelmaking shops and 66% on rolling mills plus auxiliary equipment. During this period, the emphasis of investments shifted in a direction inverse to the production flow. At first, investments were primarily made in rolling mills since the market demanded rolled steel products. Then followed steelmaking shops and finally blast furnaces.

The rapid technological progress made by the steel industry entailed a considerable change in the criteria of optimum plant and company size. At present, there is hardly any doubt left in the world steel industry that the optimum size of integrated steel mills ranges from 10 to 15 million tons of crude steel per year, depending on the respective production programmes. Sometimes, even 20 million tons per year are mentioned. Japan has been extremely successful in implementing this policy. Germany has not reached this point yet.

However, the Thyssen Group has come close to this target. It has taken some 20 years for August Thyssen–Hütte, with its 400,000 tons of crude steel in 1952/53, to reach the present structure of the Thyssen Group with a crude steel capacity of some 15 million tons. This development is largely to be credited to Dr. Sohl who was president of August Thyssen–Hütte for 20 years and, among other things, the first president of the International Iron and Steel Institute.

A new move towards rationalization was adopted by the Thyssen Group and Mannesmann AG. In 1969/70, division of work was achieved for the production of tubes and rolled steel products. Mannesmann AG and August Thyssen–Hütte AG hold a 2/3 and a 1/3 interest respectively in the joint subsidiary "Mannesmannröhren–Werke AG". It is in this subsidiary that the tube production of both companies was concentrated. At the same time, Mannesmann AG irrevocably assigned to August Thyssen–Hütte AG its rolled steel divisions.

In the meantime, the Thyssen Group had made another important step towards reinforcing its activities by the proposed merger with Rheinstahl AG. Rheinstahl only nominally belongs to the companies of the coal and steel industries. Therefore, on the steel side the Thyssen Group does not undergo any substantial increase in size as a result of the merger with Rheinstahl AG. But, in the field of steel fabricating, this merger offers the Thyssen Group a chance to complement its product mix in areas where it had not been active previously. Still more important for both the Thyssen Group and Rheinstahl AG, however, are the possibilities of rationalization resulting from their cooperation.

2. Wage and social security policy

The wage and social security policy in the German Federal Republic is of a complex nature and differs noticeably from that existing in Japan. Therefore, mention can be made here only of the most important facts created by the empolyers and the trade unions on the basis of governmental legislation and wage autonomy.

The trade unions, whose organizational structure in the German Federal Republic is industry–oriented rather than company–oriented as in Japan, have always had a strong influence on the employees of the German steel industry. After the war, this position was reinforced by the "Right of Co-Determination for the Coal and Steel Industries", which had been claimed by the trade unions, supported by the Allied occupation forces during decartelization, and finally adopted by a legal act in 1951. Briefly, this right of co-determination means that the supervisory boards of the steel mills and coal mines are equally made up of shareholders and employees. The executive officer in charge of personnel and social welfare (Arbeitsdirektor) of a company falling within the scope of the right of co-determination cannot be nominated without approval of the majority of the employees on the board.

The right of co-determination on a parity basis in the coal and steel industries is much more comprehensive than that of the rest of the German industry which is governed by a one-third parity. The right of co-determination for the coal and steel industries permits not only the employees of a company but also the trade unions to take part in the company's decision-making.

It is easy to understand that the pro and con arguments in this field have been playing an important role in socio-political discussions in the German Federal Republic for many years.

The trade unions and the employers' federation have agreed on considerable improvements in the labour conditions for the employees during the past 20 years. Thus, the negotiated working time of up to 56 hours per week was gradually reduced to the present level of 40 hours per week. At the same time, the right for paid leave rose-also gradually-from 18 to 28 weekdays (24 working days). The negotiated wage has risen fourfold since 1953. Extras and special payments have been increased considerably or established for the first time.

These were the most spectacular collective bargaining trends. But, not all of the negotiated collective rates-no matter how significant they may be-can be expressed in definite figures. Through social legislation in the German Federal Republic, for instance, the government-controlled old-age pension has been improved by means of dynamic adaptation to the increase in wages. Recently, the adoption of the flexible old-age limit has allowed employees to receive old-age pensions at 63 years of age already (as against 65 years of age previously).

In addition, the legally warranted continuation of wage payments in case of sickness, for a period of six weeks from the start of sickness, has further strengthened the employees' social security.

The social achievements can be viewed with great satisfaction. But, at the same time, mention should be made of the fact that an increasing standard of living and social welfare require funds which have largely to be raised by industry. In recent years, after having already been adversely affected by problems of a cyclical economic nature, the German steel industry's earning power has been further weakened by the steadily increasing burden of personnel and social charges. As a result labour costs exceeded the productivity growth rate by more than one third for the period from 1968 to 1972 alone.

3. Technical development

After this survey, the technical development is

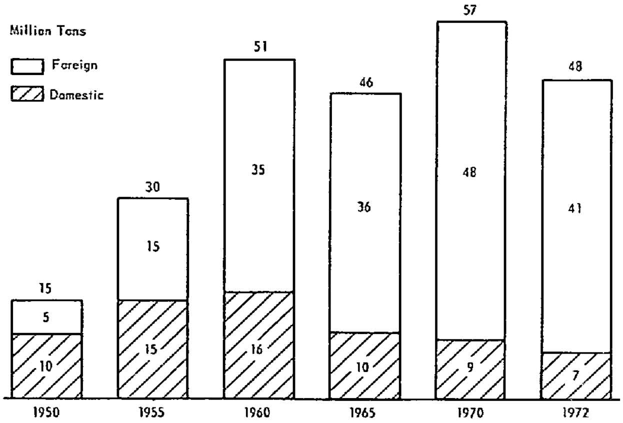

Fig. 5. Ore supplies.

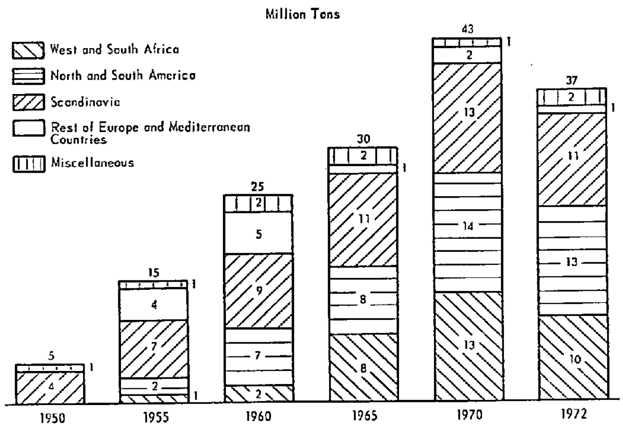

Fig. 6. Origin of overseas ores.

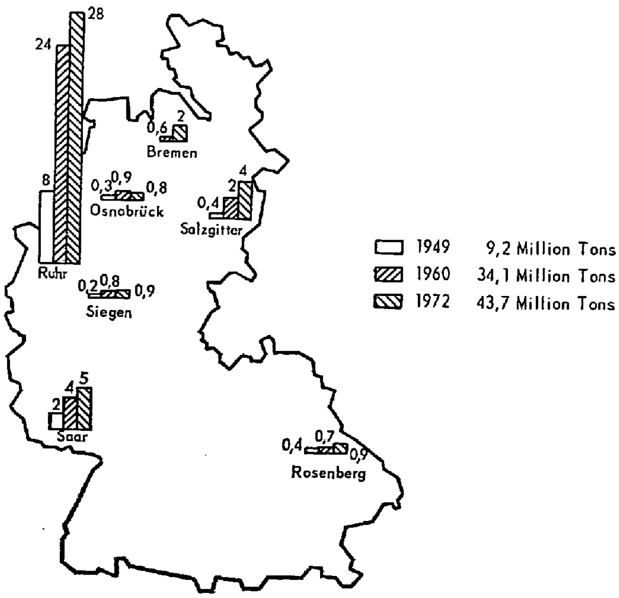

Fig. 7. Crud steel production in the various steelmaking areas.

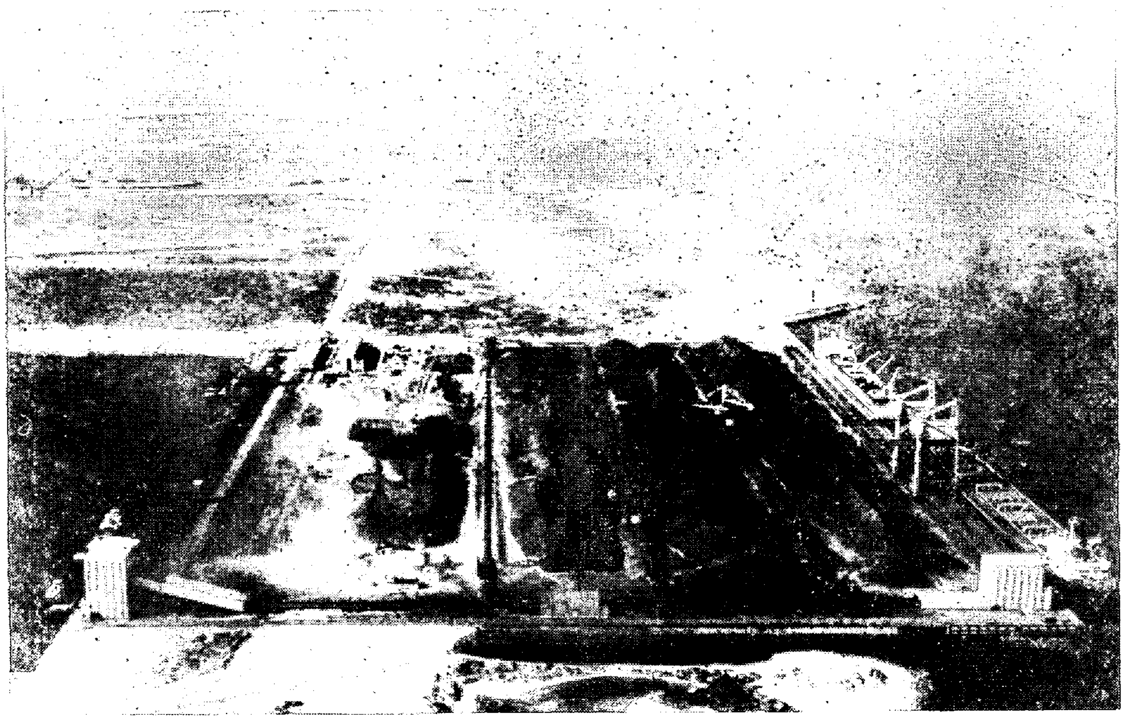

Photo. 1. Europoort ore handling facilities.

going to be described in greater detail. For that purpose, the format of the three different periods is abandoned to allow the description to follow the production flow from the ore to the finished products.

3·1 Ore supply and pig iron production

During the past 25 years, a clear change occurred in supplying the ore requirements of the German steel industry (Fig. 5). The home iron ores with their low Fe percentage gradually were unable to compete with foreign ores. At present, foreign ores account for roughly 85% of the total ore supply. The Scandinavian mines have been important ore suppliers for Germany for decades. Since 1950, however, their share has been diminishing in favour of American and African ores which, at present, account for about 60% of the ore supplies from overseas (Fig. 6). The average transporting distance increased accordingly. It now averages 3,500 nautical miles.

To secure its ore requirements the German steel industry has not restricted itself to long-term supply contracts alone; it has also acquired and developed interests in overseas iron ore mines, in Brazil and Liberia, for instance.

After the war, the German steel mills were rebuilt on their former sites (Fig. 7), except for the erection of a new mill of the Klöckner group in Bremen. The center of the German steel industry is located in the Rhine-Ruhr area. 63% of the total crude steel of the Federal Republic of Germany was produced here in 1972. The steel mills on the Rhine river are supplied exclusively with overseas ores. The most important European seaport with seven bulk goods handling facilities is Rotterdam. Almost 60% of the overseas ores for the German steel mills are unloaded here.

In 1970, three German steel mills jointly commissioned the Europoort ore handling facility (Photo. 1). At present, 16 million tons of ore can be handled there annually. At the same time, Europoort is used as a buffer-type stock yard with 1.8 million tons capacity. Another ore handling facility for 12 million tons annually is under construction in the same area and will be commissioned in 1974. A depth of 21 m at the pier allows ships up to 275,000 dtw to be unloaded.

The 250 km distance between the seaport and the Rhine-Ruhr steel mills is covered in about one day by quick push-boat units of 11,000 tons capacity, thus bringing the Ruhr area close to the sea (Fig. 8). The ore freight rates on the Rhine are less than 1% of the average returns per ton of finished products.

The efforts to step up burden preparation had an early start in Germany due to the knowledge acquired in the field of physical burdening. The ore crushing and screening facilities were expanded as well as the sintering capacities (Fig. 9). The technology of pelletizing which originated in the United States offered an alternative solution in the mild-1950s. Purchasing of pellets produced in the mines was for some time limited by the re-

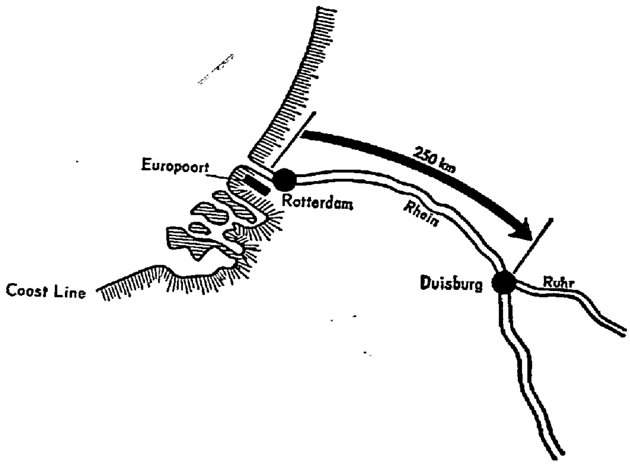

Fig. 8. Push-boat between the seaport and the Rhine-Ruhr iron and steel works.

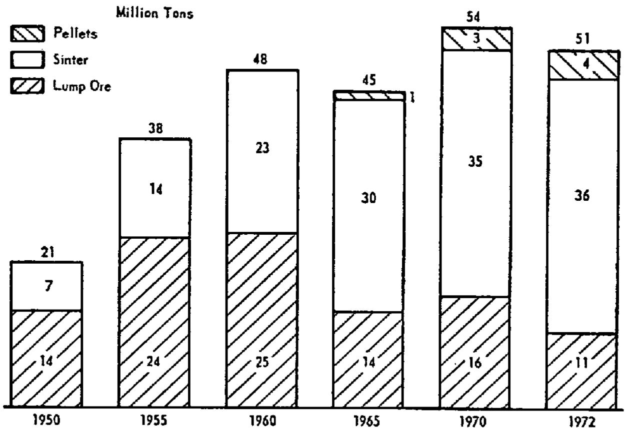

Fig. 9. Burden materials.

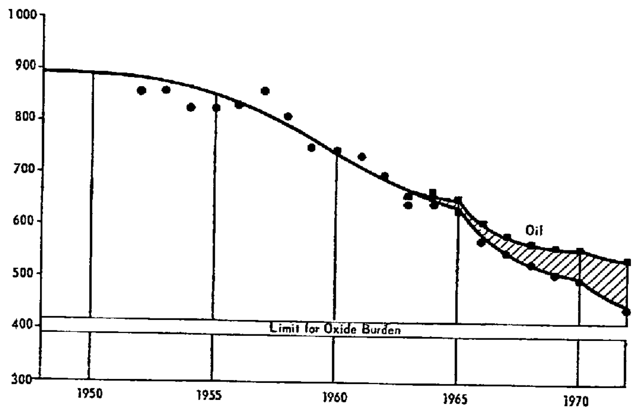

Fig. 10. Coke (dry) and oil consumption per ton of low-phosphorus pig iron.

latively high price. Therefore, preference was given to the construction of sintering facilities.

At present, the sinter percentage in the total ore burden is 70% in the German Federal Republic. With 7%, the percentage of pellets still is relatively low.

The advantages and disadvantages of pellets and sinter have frequently been discussed. Today, both products can be considered equivalent, provided adequate production is ensured. The sum total of these charging materials rather than the pellet/sinter ration should be important for the performance of the blast furnace.

According to the experience gathered so far, lump ore, pellets, and sinter should be screened once more immediately prior to being charged into the blast furnace. The percentage of fines with less than 5 mm grain size in the burden should thus be limited to 5% maximum.

The increase in burden yield and the improvements in blast furnace technology have led to nearly 50% reduction in coke rate since 1952 (Fig. 10). This result is of particular importance for the German steel industry because the mining costs and price of German coking coal have shown a highly unfavourable trend during the past few decades. At present, they are higher than those of the competing overseas coal. Contractual commitments towards the Ruhr coal mines and the economic policy of the government have so far prevented the German steel industry from using imported coal.

Due to the diminishing coke rate, the existing coking capacity has so far been sufficient. The erection of new coking plants must therefore be viewed today as replacing investments with considerable rationalization effect.

To increase the range of usable coals and obtain an optimum coke size for the blast furnace, a number of blast furnace tests have been conducted in the German Federal Republic, using shaped coke and hot briquets. However, due to the suitability of the Ruhr coal for conventional coking, this development has not yet been given any priority.

Steel production in the 1950 s was mainly based on the basic Bessemer process (Fig. 11). The progress made by the basic oxygen steelmaking process has caused the percentage of high-phos-

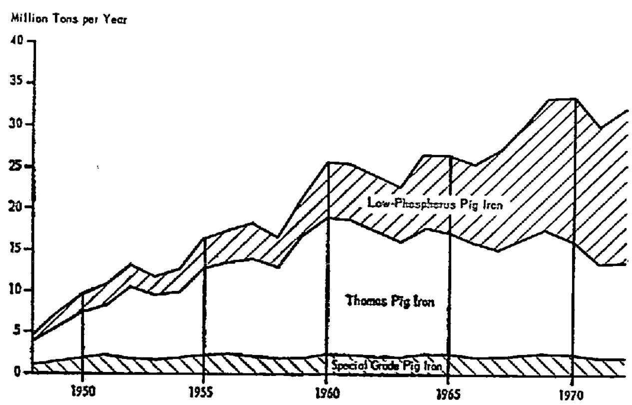

Fig. 11. Pig iron production in the federal republic of germany.

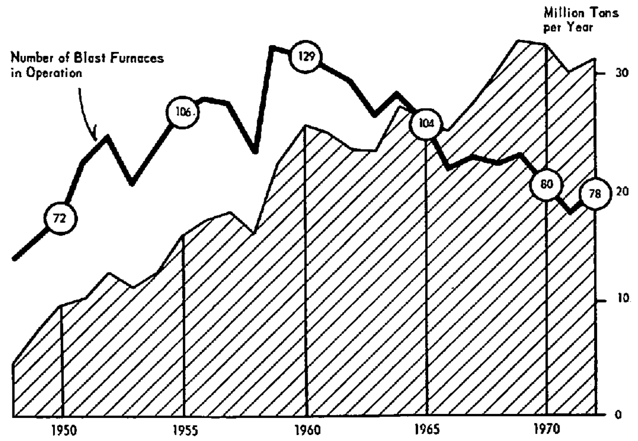

Fig. 12. Pig iron production and number of blast furnaces in the Federal Republic of Germany.

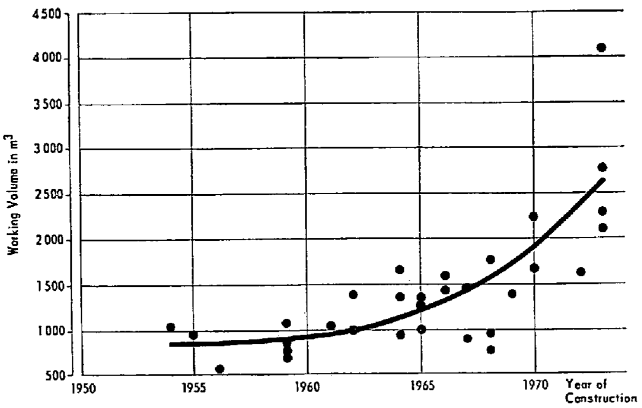

Fig. 13. Trend of working volume of blast furnaces producing low-phosphorus pig iron.

phorus pig iron to drop to 37% in 1972. But, with 12 million tons per year, it still is a sizable factor. In the basic oxygen converter, this type of pig iron is used for specific grades. This is mainly due to economic reasons. In future, this percentage is likely to continue to drop. The bulk of the high-phosphorus ores is coming from Sweden, at low freight rates, and can be used together with other circulating materials.

A great number of old, small blast furnaces are still in operation in the German Federal Republic (Fig. 12). In Japan, big units were built along the coast from the very beginning of the steel industry's expansion, whereas in Germany the changeover to large-size blast furnaces did not occur until in recent years. In 1960, a total of 129 blast furnaces were still in operation in the German Federal Republic. By 1972, the number of blast furnaces had dropped to 78.

The trend towards large-size blast furnaces is evidenced by the fact that in Germany, for low-phosphorus pig iron, only blast furnaces of more than 1,450 m³ have been built (Fig. 13) since 1969.

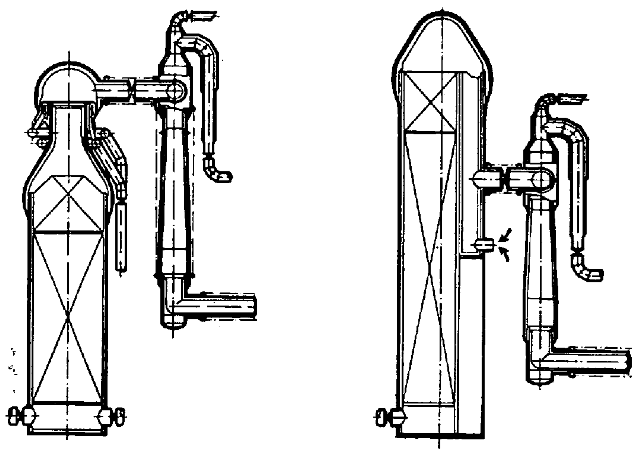

Fig. 14. New systems of hot blast stoves.

Early in 1972, a 14-meter blast furnace having 4, 084 m³ inner volume was commissioned at August Thyssen-Hütte. Since Japan, too, has blast furnaces of this size, particular mention shall be made here only of the tonnage oxygen plant of this furnace. Its capacity is 70,000 Nm³/hr for 60% oxygen. This has eliminated the inconvenience of fluctuating oxygen availability due to the former system of supply from the tonnage oxygen plants of the steelmaking shops. Besides, oxygen of medium concentration is less expensive.

The trend towards blast furnaces of modern size must be credited to the worldwide achievements in blast furnace technology to which Japan and Germany particular, made a considerable contribution. An important prerequisite for blast furnace development was the success obtained in hot blast generation which is a good example of co-operation between the German steel mills within the framework of Verein Deutscher Eisenhüttenleute.

A set of hot blast stoves having an external combustion chamber and silica lining in the upper third was built as a large-scale pilot plant in Salzgitter in 1962. In Japan, a plant of this type was built by Nippon Kokan Kabushiki Kaisha in 1963. Today, due to the high investment costs for equipment of this type, development of new types is being considered, such as hot blast stoves without any combustion chamber or with a shortened internal combustion chamber (Fig. 14).

Apart from reducing the coke rate through high blast temperatures, new ways and means have been investigated to replace the expensive metallurgical coke by increased amounts of the less expensive fuel oil. In recent years, in cooperation with an oil company, August Thyssen-Hütte AG has developed a process which allows an increase in fuel injection up to 140 kg per ton of pig iron-through an oil-water emulsion-without any formation of carbon black and no oxygen enrichment of

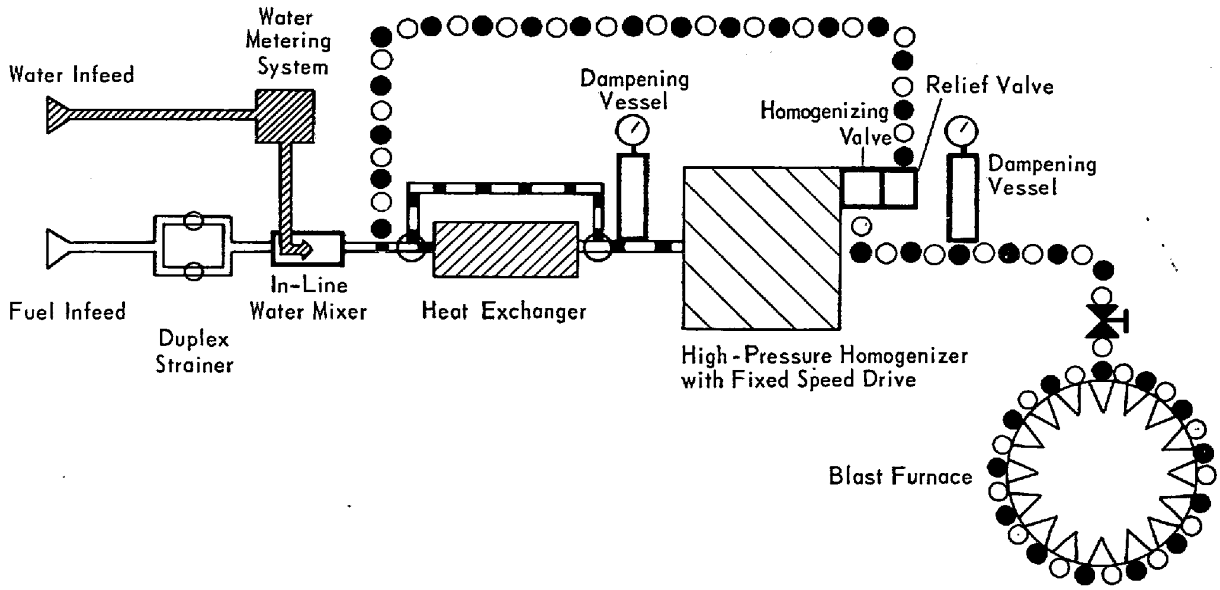

Fig. 15. Diagrammatic layout of oil injection system with emulsifier.

the blast to attain 1000°C blast temperature (Fig. 15). Likewise, this process is of interest for large-size blast furnaces operating with oxygen enriched blast because this will allow the use of even greater amounts of oil.

It is well known that an even distribution of gas throughout the stack is a decisive factor for blast furnace performance and fuel consumption. Therefore, German blast furnace engineers have been endeavouring to control the heaping inside the furnace with a view to obtaining food gas distribution.

These efforts have led to the development of an adjustable throat armour, without which no bell-type top closing equipment of a large-size blast furnace, would be conceivable. Another development is a new type of top closing device with a rotating chute for the charging materials (Fig. 16). This chute rotates around the furnace axis, and its inclination is adjustable. Subject to each respective operation requirement, the charging materials can thus be distributed accordingly throughout the throat cross section. Grain segragations are largely avoided. There are a number of economic advantages due to the relatively low investment costs, the anticipated reduction in repair and maintenance costs, and the shortening of downtimes.

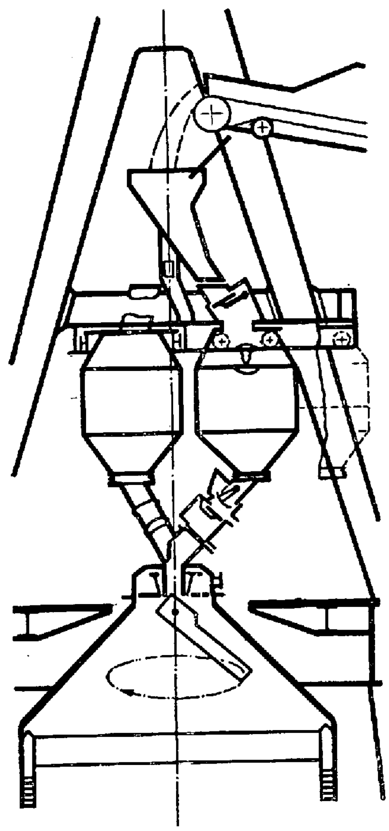

Fig. 16. Wurth-type throat with Revolving chute.

3·2 Direct reduction

Prior and subsequent to World War II, the Krupp-Renn process used coal in a kiln to reduce low-iron, acid home ores. This method of producing iron was given up as soon as high-grade foreign ores were available in sufficient quantities at a lower price. Today, due to the high coke price, efforts are being made to use different means for the reduction of iron ores. Particular mention must be made of the new methods of direct reduction.

Friedrich Krupp GmbH has developed a sponge iron process using solid reducing agents in a kiln for the reduction of lump or fine ores (Fig. 17).

Use of liquid and gaseous fuel additions is possible. Meanwhile a facility for 150,000 tons per

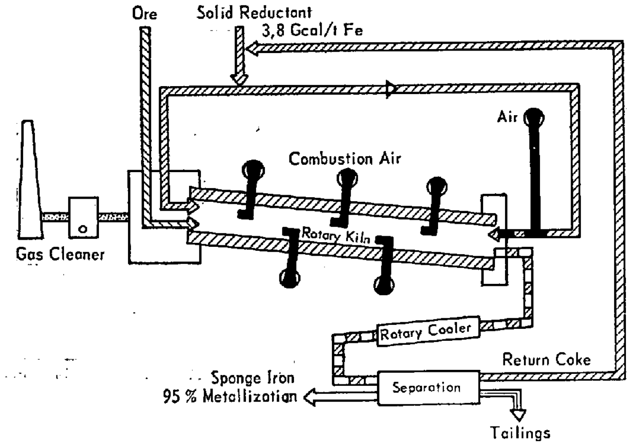

Fig. 17. Diagrammatic view of a commercial Krupp sponge iron plant for processing ore.

year was commissioned in Dunswart (South Africa).

A similar principle is used by the SL/RN process developed by Lurgi Gesellschaft für Chemie und Hüttenwesen GmbH, in cooperation with other partners abroad. This process has meanwhile found an application in a number of large-size installations.

A process developed by the Thyssen Group, i.e. the Purofer-type process, uses gaseous reducing agents in a shaft furnace for the reduction of iron ores (Fig. 18). The energy balance is a favourable one as a result of possible recirculation of the blast furnace gas.

A 500-ton/day large-size pilot plant has been in operation for some time and produced roughly 150,000 tons of sponge iron. The designing of 1,000-ton/day plants has been completed. The construction of such production plants abroad is imminent.

The direct reduction processes will not be capable of replacing the blast furnace in the foreseeable future. But, with low cost energy and with suitable ores, these processes will increasingly be used as an alternative to the conventional technology.

For use in blast furnaces it might be interesting to envisage pre-reduced pellets made in direct reduction facilities because of their possibility further to reduce the coke rate and to increase the blast furnace performance, for instance, for bridging such gaps as are caused by furnace relining. The future price ratio between coke and natural gas will largely govern this trend. In addition, sponge iron made from pure ores creates another possibility of increasing the performance of electric furnaces through continuous charging; besides, due to its purity, it is particularly suited to the making of high-grade steels.

3·3 Steelmaking shops

Steelmaking in the German Federal Republic during the past ten years has been characterized by the progress made by the basic oxygen steel process (Fig. 19). Following the first technical application of the process by Vereinigte Österreichische Eisen- und Stahlwerke AG in Austria in 1951, the first converters were started up in the German Federal Republic in 1957. Today, basic oxygen steel accounts for 65% of total crude steel production in the German Federal Republic. At August Thyssen-Hütte, basic oxygen steel represents 93% of its total crude steel production.

The particular situation of the ore supply in Europe has already been mentioned. Processes for treating high-phosphorus pig iron in BOF converters

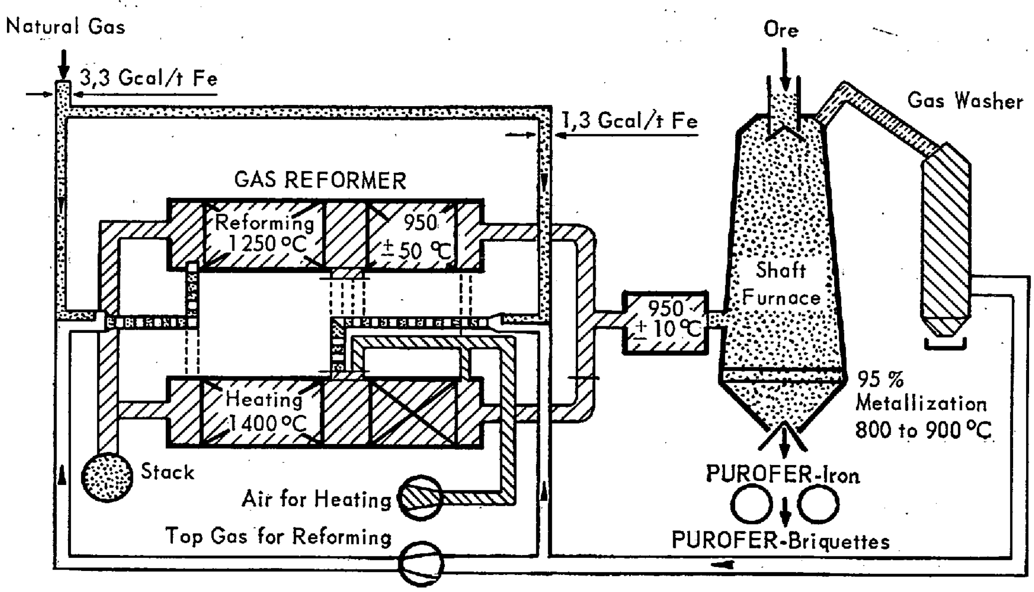

Fig. 18. Diagrammatic view of a PUROFER installation.

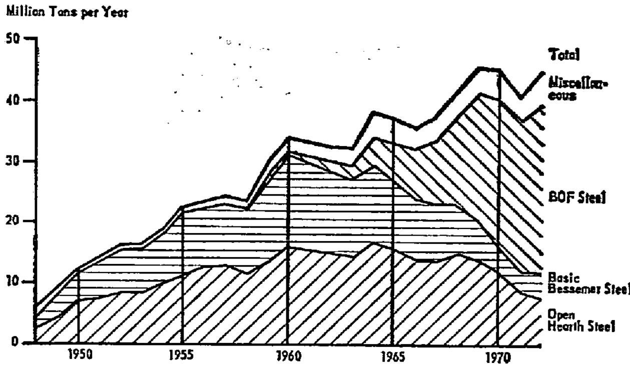

Fig. 19. Crude steel production in the Federal Republic Germany.

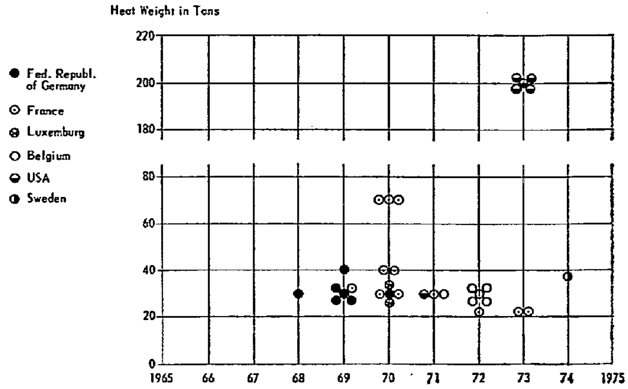

Fig. 20. OBM-converters in operation and planned.

have been developed in the German Federal Republic at an early stage. In most cases, an intermediate slag change is necessary. In the case of what is known as the LDP process it is possible to work with one slag only. The final dephosphorization here takes place in the ladle. The BOF process is not going to be described here in more detail because a paper was presented on this subject during the 6th annual meeting of the International Iron and Steel Institute in London.+)

Prior to the widespread adoption of the basic oxygen steelmaking process, attempts were made by many German steel mills in the 1950s to increase the percentage of oxygen in the air in bottom-blowing basic Bessemer converters with a view to stepping up the percentage of scrap in the charge and reducing the adverse percentage of nitrogen in crude steel. However, with increasing oxygen content, the temperature increased to such an extent at the outlets of the bottom nozzles that the bottom and converter service life was appreciably reduced.

It is Maxhütte in Sulzbach-Rosenberg in Bavaria that must be credited with using hydrocarbons as cobalts to allow the bottom-blowing converter to use pure oxygen for steelmaking.

This method is called the OBM process. Its particular features are:

—low investments as a result of reduced height of the plant;
—possibility of modifying existing steelmaking facilities at low cost;
—high tapping weights related to the converter volume;
—high yield;
—high scrap rate as a result of favourable thermal balance.

At present, the capacity of OBM converters

+) Brandi H. *Th.*: Development and actual state of basic oxygen steelmaking. In: Rep. of Proc. 6 Annual Conf. HSI 1972 London, S. 95-122.

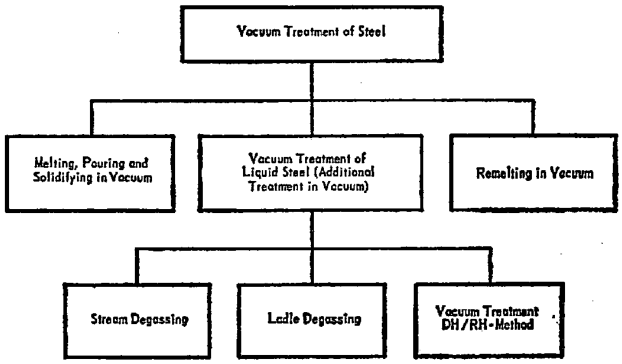

Fig. 21. Methods for vacuum treatment of steel.

throughout the world is already approximately 7 million tons. By the end of this year, it will be some 15 million tons.

So far, units mostly up to 70 tons in tapping weight operate on the basis of the OBM process; in most cases, these were modified basic Bessemer converters (Fig. 20). It is difficult to compare the operating results of these small units with those of big LD converters. It remains to be seen whether the 200-ton converters commissioned by United States Steel at Gary Works this year will offer such substantial advantages as to cause the trend towards big OBM converters to continue and lead to the eventual replacement of LD converters.

The adoption of vacuum metallurgy in steelmaking originated in Germany (Fig. 21). It was based on experiments and the large-scale adoption of continuous degassing at Bochumer Verein für Gu*ß*stahlfabrikation AG by Mr. Arthur Tix. Other German steel mills followed suit with processes of their own. It was only through the development of efficient vacuum pumps for the rough conditions existing in steel mills that vacuum metallurgy as a whole could come into being.

In the field of high-grade steels, the DH-type process developed by Dortmund-Hörder-Hüttenunion AG and the RH-type process developed by Rheinstahl Hüttenwerke AG, Henrichshütte, in Hattingen, have found worldwide recognition. In addition, for high-alloy steels, the ladle degassing and the vacuum remelting processes have acquired special importance in producing steels of the highest possible purity.

The original objective of vacuum degassing was the removal of hydrogen from steels which are susceptible to flaking. Today, these processes are used for an increased number of metallurgical treatments, such as refining of high-chromium steels by means of pure oxygen, deoxidation aiming at target values, adjustment of lowest carbon contents, and high-precision alloying.

The combination of melting unit and degassing unit may be considered a virtual 2-stage process. Therefore, the operational reliability nowadays must be the same for both the vacuum unit and the melting unit.

These problems are solved now. As August Thyssen-Hütte AG, for instance, use is made of vacuum facilities based on the RH and DH-type processes. The DH-type facility handles charges of 400 tons average weight. Thus, based on information available, it is the largest steel degassing facility in the world. It is mainly used for making electric sheet and rail grades.

Continuous casting technology dates back to the work done by Mr. Siegfried Junghans on non-ferrous metals before World War II. It was in 1949 that steel was cast successfully on a vertical continuous casting machine for the first time in the German Federal Republic (Fig. 22). The first 4-strand billet casting machine was put in operation by Mannesmann Hüttenwerke AG in 1954. The successful use of a curved ingot mould by Mannesmann AG in 1963 gave impetus to the rapid, worldwide expansion of the continuous casting capacity.

The billet and blooming facilities existing in the German Federal Republic are mainly used today to produce plain carbon steels. In addition, there is a trend towards the production of quality steels through continuous bloom casting machines. Slabbing facilities are mainly used to make slabs for plate and hot strip production. Primarily for economic and quality reasons, a changeover to continuous casting was decided upon for killed steel grades.

Mild rimming steel grades for sheet production have so far been largely poured conventionally for economic reasons. But, here too, there is a worldwide trend towards replacing the rimming-grade ingot pouring by killed-grade continuous casting. The German steel industry will take it into account during the forthcoming years.

The planned facilities and those under construction are characterized by variable slab widths,

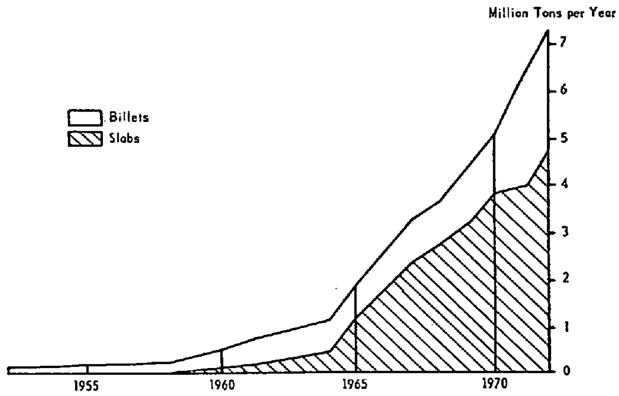

Fig. 22. Continuous casting capacity in the Federal Republic of Germany.

high casting speeds, and short auxiliary times. Present facilities are designed for heats of 300 tons and capacities up to 1·5 million tons per year.

3·4 Steel forming

Due to the vastness of this field, mention can be made here only of the most outstanding developments. Following World War II, the existing technology was used in the field of structural shapes whereas in the field of flat steel products the German Federal Republic followed the American example of hot strip rolling in the early 1950s.

The first German hot strip mill was built by August Thyssen-Hütte AG before World War II. It was dismantled in 1945/46. In its place, a 66″ mill was started up in 1955 as the first hot strip mill built in the German Federal Republic after the war.

Ever since, great progress has been made worldwide in hot and cold rolling, above all through automation of the processes. In 1967, the first slab was rolled on the universal slabbing mill at August Thyssen-Hütte AG by means of an on-line computer. Last year, a 6-stand tandem mill was put in operation at Rasselstein AG for cold rolling of tinplate. This mill is largely automated.

For cold rolling of steels which are difficult to form, mention should be made here of the MKW-type stand developed in Germany; this mill closes the gap between the 4-high stands and the multiple-roll mills. It has been successfully operating in the meantime in many countries. Last year, the first MKW-type tandem mill in the world was commissioned by Hoesch-Hüttenwerke AG.

For rolling of seamless tubes, a continuous tube rolling mill was started up in 1965 by Phoenix Rheinrohr AG, a former company of the Thyssen Group. It was specifically designed to meet the German market's demand for small lots of rolled products. Late last year, a second continuous tube rolling mill was commissioned by the same company which was meanwhile transferred by August Thyssen-Hütte AG to a new tube rolling mill founded jointly with Mannesmann AG (Fig. 23). Good service life allows the rolling of steel grades up to 9% chromium in heat resistant quality. Thus, the tube rolling mills cover the entire range of grades below those of alloyed steels to be made by extrusion.

The spiral-welded tubes which were used for less stringent applications only up to 1950 have

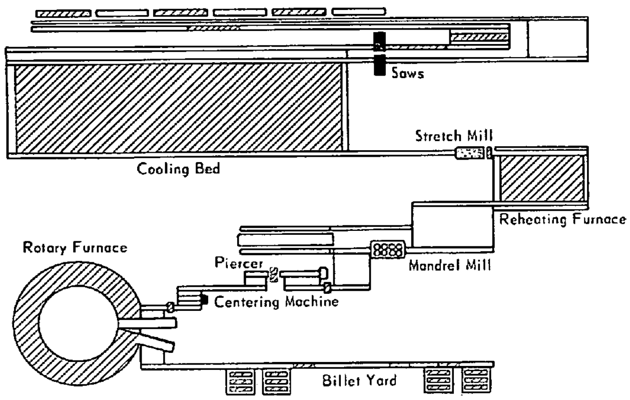

Fig. 23. Layout of Mandrel mill at Mannesmannröhren-Werke.

attained such a high degree of perfection during the past 20 years that they are equal in quality to that of longitudinally welded large-diameter tubes. This development started, with respect to welding on both sides, from a patent submitted by Phoenix Rheinrohr AG in 1944. This patent remained unused for a long time since the technical people initially did not believe in the future of this process. It would be beyond the scope of this paper also to cite the developments made in the field of rod mills, forging machines, and tyre rolling mills. The same holds true for surface coating and further processing.

4. Pollution control

The equipment of our production facilities has changed during the past 25 years. The technical progress made so far has allowed them to become less harmful for environmental life. The steelmaking people share the concern about man's existence which is joepardized by the adverse effects of pollution, and about preservation of the natural environment.

The German steel industry has met this challenge in good time, and especially in the densely populated area along the Rhine and Ruhr rivers, it has

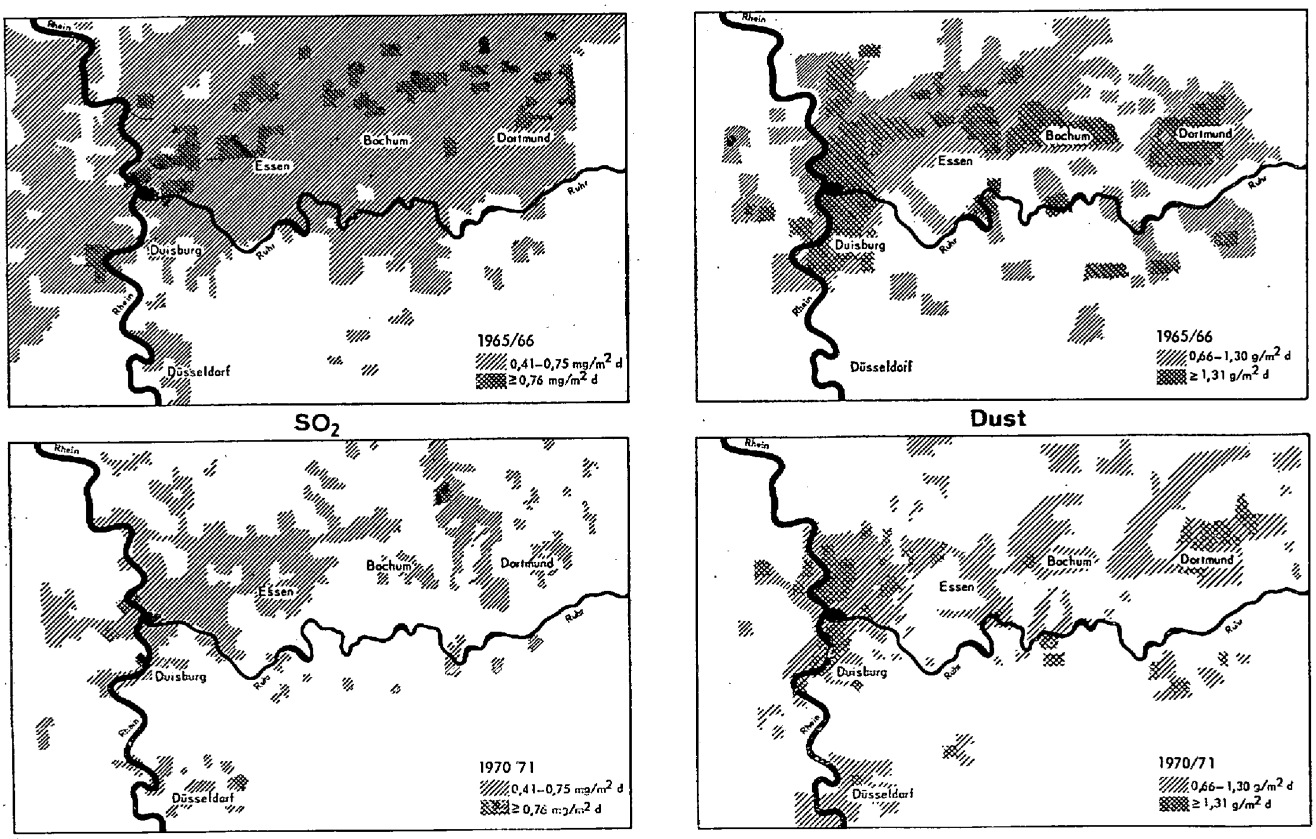

Fig. 24. Decrease of dust and sulphurdioxide pollution in the Rhine-Ruhr-area between 1965 and 1970.

made an important contribution to the improvement of living conditions. The exemplary reduction in dust and sulphur dioxide pollution in this area between 1965 and 1970 is shown in Fig. 24.

In the German steel industry, 82% of the cooling water is recycled for multiple use, and practically no water is discharged any more untreated into the rivers. From 1961 to 1970, the German steel industry invested a total of DM 1·1 billion for pollution control. Of this amount, 52 and 43% were used respectively to keep the air and the water clean. These sums account for a total of some 7% of all investments made. Operation and maintenance of these facilities naturally amount to a figure which is several times that of the investment costs.

These expenses show an upwards trend. For future investments, a total of 10–12% is expected to account for pollution control. In particular cases, this amount might even be higher. For the 14–meter blast furnace at August Thyssen-Hütte AG, for instance, it accounts for some 15% of the total investments.

All industrial countries are faced with similar problems of pollution control. A worldwide harmonization of environment legislation should be a matter of urgent consideration.

5. Joint institutions sponsored by the steel industry and the universities

Technical progress requires an exchange of ideas and experience as well as great efforts in the field of research and development. In the German Federal Republic, this takes place at the institutions sponsored by the steel industry, and the universities (Fig. 25).

The mission of Verein Deutscher Eisenhüttenleute which was founded as early as 1860 is to promote technical and scientific work in the field of iron and steel, and related materials, on a non-profit basis. Its activities are carried out in permanent contact with the steel mills, research and univeristy institutions, steel consumers and subcontractors.

In conjunction with Max–Planck–Gesellschaft, Verein Deutscher Eisenhüttenleute supports the Max–Planck–Institut für Eisenforschung in Düsseldorf. The link between fundamental research carried out here and the industrial objectives assigned to each company's research department is the Betriebsforschungs–institut founded in 1968 and forming part of Verein Deutscher Eisenhüttenleute; it is entrusted with industrial research and development for the steel industry.

Increasing emphasis is placed on supplementary

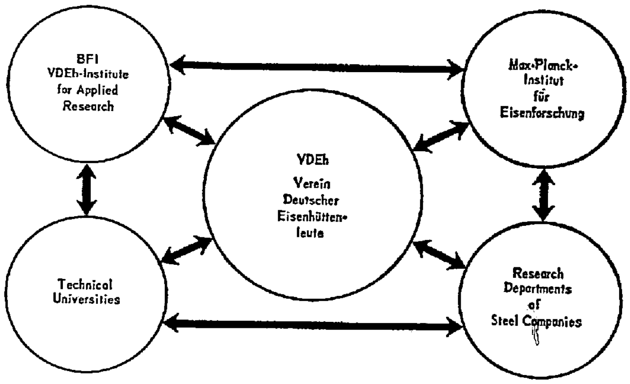

Fig. 25. Joint institutions supported by the steel industry.

training of our engineers through training courses and seminars, study travels and international engineer exchange programs.

For the education of our future engineers there are three Technical Universities in Aachen, Berlin, and Clausthal. Verein Deutscher Eisenhüttenleute sponsors research carried out at the universities and supports some of the students. Unfortunately, the number of students engaged in studies of iron and steelmaking has diminished, so it is becoming more and more difficult for our industry to meet the growing demand for iron and steelmaking engineers.

6. International cooperation

A survey of the German steel industry's development cannot be completed without mentioning once more the economic integration within the European Economic Community. Early this year, Great Britain, Ireland, and Denmark joined the Community, bringing the number of its members to a total of nine. The crude steel production of the enlarged community was 139 million tons in 1972. This accounts for about 22% of the world crude steel production. This year, 150 million tons may be reached.

Economic and political unity of Europe undoubtedly still has a long way to go. But, integration will make further progress, and the German steel industry is supporting any efforts made in this direction.

German steelmaking engineers feel it is necessary for the steel companies to cooperate world-wide beyond the framework of the European countries. This holds particularly true for the technical side. Therefore, the foundation of the International Iron and Steel Institute was highly welcomed in Germany. It is here that mutual problems can be solved and experiences can be exchanged.