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ENERGETICS OF THE IRON AND STEEL INDUSTRY [1]

by

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SUMMARY

ENERGETICS OF THE IRON AND STEEL INDUSTRY [1]

by

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This paper describes the development of energetics of the Soviet Union iron and steel industry over a period of 50 years. It considers principal kinds of by-product energy resources used in the iron and steel industry and those of the energy yielded by the by-products in production processes.

The development of energetics is shown in connection with the rapid growth both of metal production and of operational unit capacities.

Periods of forced delaying in the development of iron and steel industry energetics in the time of intervention (1918-1921) and the Great Patriotic War (1941-1945) are marked in the report; its rise and progress in followed years are shown.

It is noted that even in the years of war enormous work was carried out for displacing the metal production to the East and for increasing the energy capacities. This created a possibility to produce more electrical power already in 1945 than in the pre-war 1940.

The Energy balances of the iron and steel industry" section gives the characteristic of fuel balances, their pattern and development for a number of years. The effect of natural gas use on the fuel balance pattern is considered as well as that of intensification of blast furnace production on decreasing the blast-furnace gas output.

Fuel utilization in metallurgical processes and for power-heat and compressed air production is discussed as well as the specific fuel consumption for the principal kinds of production.

The "Energy providing and power supply " section shows the provision of metallurgical units with electrical equipment, its modernization, improving the control systems, automation of drives and telemechanization of power supply system.

Increasing the power consumption in the iron and steel industry and rising its production at the works power stations are shown. Due to the development of energy network and district power stations the share of power generated by works power stations in its total consumption in the iron and steel industry decreased from 63 pct in 1950 to 25 pct in 1967.

The "Heat supply" section describes the development of heat supply of enterprises and neighbouring towns. The characteristic of heat balance of the iron and steel industry is given according to the heat supply sources and their development by years.

The iron and steel industry is a large source of by-product energy. The "By-product energy" section considers the by-product heat and fuel sources, the parameters of waste-heat installation operation, their productivity and efficiency.

The data of waste-heat boilers, evaporative cooling invented and widely used in the Soviet Union, waste-gas hoods of oxygen convertor shops are given. The methods of utilizing the surplus energy of gas pressure (1.5-2.0 atm.abs.) for exhauste-gas turbines for the first time used in the USSR are pointed out. Relative values of blast-furnace gas yield and of its loss decrease are given for 25 years.

The largest in the world coke dry quenching stations utilizing hot coke heat are described.

The "Water supply" section gives the schemes of water supply and the data of water consumption in the iron and steel industry. The large water requirement led to a necessity of building artificial water storage reservoirs, channels, sewage disposal plants, plants for supplying boilers with water, power-and waste-heat installations.

The "Compressed air supply" section gives the technical characteristic of installations and equipment to provide compressed air for blast furnaces and air-separation apparatus at oxygen plants and for technical needs of the production shops of enterprises.

The "Power and air-blast stations" section shows the development of stations relative to capacities and steam parameters of boiler units, turbogenerators and turbocompressors. An extensive use of high parameter steam is noted as well as combined heat-and power production.

The importance of establishment of metallurgical enterprises and development their energetics in poorly developed areas of the country on rapid industrial development, growth of population, planning and organization of public services and on cultural progress of these area is shown.

The "Oxygen use in iron- and steelmaking" section deals with the effect of the iron- and steelmaking intensification on the development of oxygen stations. The increasing of capacity of air-separating units and of the output of oxygen stations are outlined as well as increasing the productivity and capacity of compressor installations. An outlook of oxygen station development is considered taking into account the requirements for the oxygen purity.

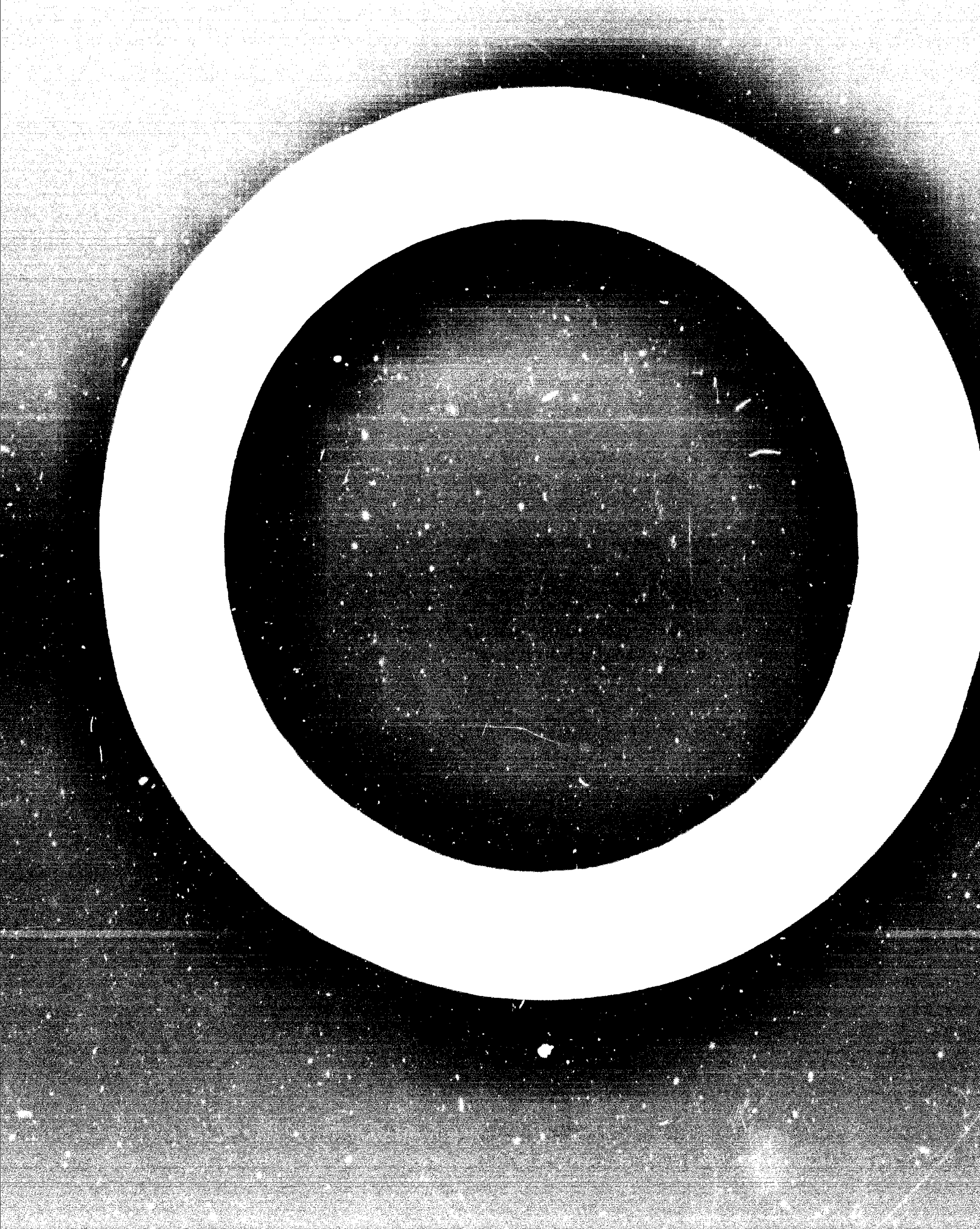
The "Automation" section gives the data of development of production process automation in the iron and steel industry and of the effectiveness of automation of separate units. The status of automation of principal processes of iron and steel industry and the technical principles of some automatic arrangements are given.

The "Air- and water pollution control" section illustrates the measures for gas cleaning and sewage disposal carried out in the iron and steel industry. The results obtained are pointed out.

The "Organization of energy equipment maintenance and repair" section makes an account of principal problems. The expediency of centralization of energy equipment heavy repairs at specialized trusts and industrial enterprises is outlined.

The "Outlook of energy economy development" section sets forth the main trends of developing the energy economy of the iron and steel industry for the full provision of the production consumers with all kinds of energy as well as the problems of improving its techno-economic characteristics.

The further development of the iron and steel energetics will be carried out with installation of the newest equipment, with modernization and replacement of the obsolete equipment and with an extensive introduction of automation and telecontrol methods. The research institutes and specialized enterprises have been established for solving these tasks.



ENERGETICS OF THE IRON AND STEEL INDUSTRY

The scientific and industrial progress in all fields of the national economy of the Soviet Union has created conditions for rapid development of the iron and steel industry and its energetics.

The rise of production unit capacities as well as the improvement and the intensification of production processes of metallurgy are accomplished on the basis of new, powerful energy equipment and on the utilization of many kinds of energy resources.

It is especially representative for developing energetics of the iron and steel industry of the USSR.

After the Great October Socialist Revolution Russia inherited an iron and steel industry which had fallen by that time into full decay.

In 1920 the steam and electrical power production at the iron and steel works did not exceed 5 pct of the level of 1913. The energy providing was characterized by operation of the boilers with the output of 5-15 tons of steam per hour at the pressure 8-12 atm.abs., steam- and hydropower installations with the capacities up to 300 kW.

It was on V.I.Lenin's initiative that in these years the plan of restoration and development of national economy, the plan of developing the electric-power system of the country (the "GOELRO" plan) was worked out which had a great importance for the developing of the iron and steel industry energetics.

It took about a decade to restore the iron and steel industry and the obsolete energetics and to elaborate projects both for reconstruction of the existing enterprises and for constructing new ones.

Since 1930 the construction of new iron and steel works and combines was begun on the basis of the then newest technique in the fields of energy equipment and metallurgy.

Simultaneously with the development of industry in the central area of the country great attention was given to such regions of the USSR as Siberia, the Far East, the Central Asia and others which were poorly developed in industrial respect.

The experience of the industrialization of the poorly developed regions of the USSR has shown that creating metallurgical enterprises there favoured, to a great extent, the rapid developing of their economy and culture. It was the integrated iron and steel works that have been mainly built in these regions.

Power plants equipped with boilers rated for steam pressure up to 30 atm. abs. and 420°C temperature, with turbogenerators of rated capacity to 25 MW, with blast-furnace turboblowers driven by steam turbines of 12 MW capacities have been built at many of new works.

Electrical machines of higher capacity with improved control systems were used to drive the mechanisms of metallurgical units and rolling mills. An electric motor of 6,000 kW capacity was used to drive the first Soviet blooming in 1932.

The iron and steel industry energetics was subjected to considerable renovation and development in the years of the first Five Year Plans (1930-1940) due to the building of new Magnitogorsky and Kuznetsky metallurgical combines, Zaporoghstal, Azovstal, Krivoroghsky and other iron and steel works as well as to the reconstruction of Dnieprodzerjinsky, Kramatorsky and other iron and steel works.

In 1940 the total capacity of the power plants at the iron and steel works amounted to over 750 MW, which exceeded the level of 1914 ten times and the capacity of separate power plants increased up to 120 MW.

The energetics of iron and steel works expanded together with the growth of metallurgical unit capacities and with the rise of metal production overtaking the construction and the development of the iron and steel production itself.

If in 1940 steel output reached 18.3 million tons against 220 thousand tons in 1921 (i.e. it increased 83 times) then by that time electric power generation amounted to 5,375 million kWh, i.e. almost 100 times higher than in 1921.

In the years of the Great Patriotic War (1941-1945) the rates of developing the iron and steel industry and its energetics were considerably reduced. By the end of 1941 the rated capacity of the iron and steel works power plants decreased twice against that of 1940. In these years enormous work was accomplished for displacing the iron and steel works and energetic equipment to the eastern regions of the country.

In spite of the loss of the metallurgical enterprises of the south and central regions of the country in 1945 the production of electrical power at the power plants of the iron and steel works amounted to 3,372 million kWh or by 14 pct more than in 1940. The capacity coefficient exceeded that of the previous years and amounted to 92-94 pct. This was attained due to the excellent maintenance of power plant equipment.

During the post-war period the energetics of the iron and steel works of the South of the country as well as at the most of old iron and steel works of the Urals was almost completely renovated due to the installation of new and more economic equipment.

Along with the building of new enterprises of the iron and steel industry and the reconstruction of existing ones energetics has been also developed.

Presently energetics of an iron and steel works represents a large complex of different equipment which is of a considerable interest due to its composition.

<u>Energy balances of the iron and steel industry.</u>

A. Fuel and its consumption

The iron and steel industry is one of the largest consumers of fuel resources. The fuel consumption in reference fuel units (including coking coals) amounts to about 10 pct of the total fuel mined in the country. The enterprises meet about half of all consumed energy-producing fuel from the so-called by-product energy generated both in iron and coke production and when enriching coal. It is one of the main technical features of the modern iron and steel industry.

Thus, the fuel balance of an integrated iron and steel works represents an intricate complex of primary fuel and by-product fuel resources derived from the primary fuel consumption for some of production processes (blast-furnace and coke production).

Since 1957 natural gas has been used in the iron and steel industry both as the technological fuel for blast furnaces and as the energy producing fuel for melting and heating furnaces and power installations.

As a result of that the pattern of fuel balance has sharply changed. If in the total fuel balance (by heat) solid fuel (coal) amounted to 4[illegible].3 pct in 1945, then only to 16.6 pct in 1960 and to 9.5 pct in 1967, gas fuel respectively amounted to 42.6 pct, 64.2 pct and 70.6 pct (Fig. 1).

The natural gas consumption at the enterprises of the iron and steel industry amounted to 23 x 10^9 cu.m. in 1967. About 81 pct of all iron yielded in the country were produced with the use of natural gas; 65 pct of all open-hearth furnaces were converted to the natural gas heating.

The intensification of blast-furnace production is provided with the improvement of charge quality, the rise of top gas pressure, the high temperature blast (up to 1200°C), the utilization of natural gas and oxygen. The yield of blast-furnace gas decreased by 20 pct per ton of iron in recent five years.

The consumption of natural gas at the calorific value of 8000-8500 kcal allowed the deficit of gas fuel resulted from decreasing the blast-furnace and coke-oven gas output to be eliminated as well as the non-economic gas producers at the enterprises to be liquidated.

A task of great importance is decreasing the specific fuel consumption for goods output of metallurgical enterprises.

The specific fuel consumption for all kinds of products manufactured in the iron and steel industry systematically decreases. Over a period 1950-1967 the specific fuel consumption which is conventionally determined as the ratio of all amount of fuel consumed to the annual finished products output (rolled products output) decreased by 32.8 pct (Fig.2.).

B. Energy providing and power supply.

In connection with the growth of production capacities of metallurgical units and enterprises on the whole a necessity appeared for solving the problems of power supply and determining the equipment structure in some other way.

The rise of mechanization and automation level of production, which provides for the intensification of production processes required the new technical principles of electrical drive control systems in manufacturing electrical machines and instrumentation.

Automation of blast furnace charging was introduced in the USSR in 1937. The first Soviet blooming with home electrical equipment was put in operation in 1932.

By 1941 the Soviet iron and steel industry had been equipped with modern electrical equipment, which allowed the high output of metallurgical units to be ensured.

In post-war years in restoration of the iron and steel industry of the South of the country, in modernization of existing enterprises and in constructing new ones the further improvement of electrical equipment was carried out, automated electric drives and telemechanization of power supply networks were introduced.

The increase of output and capacity of existing metallurgical units required carrying out the reconstruction and modernization of electric drives (mainly of rolling mills). The motors of a capacity considerably higher (up to 7-9 MW) than those which has been used

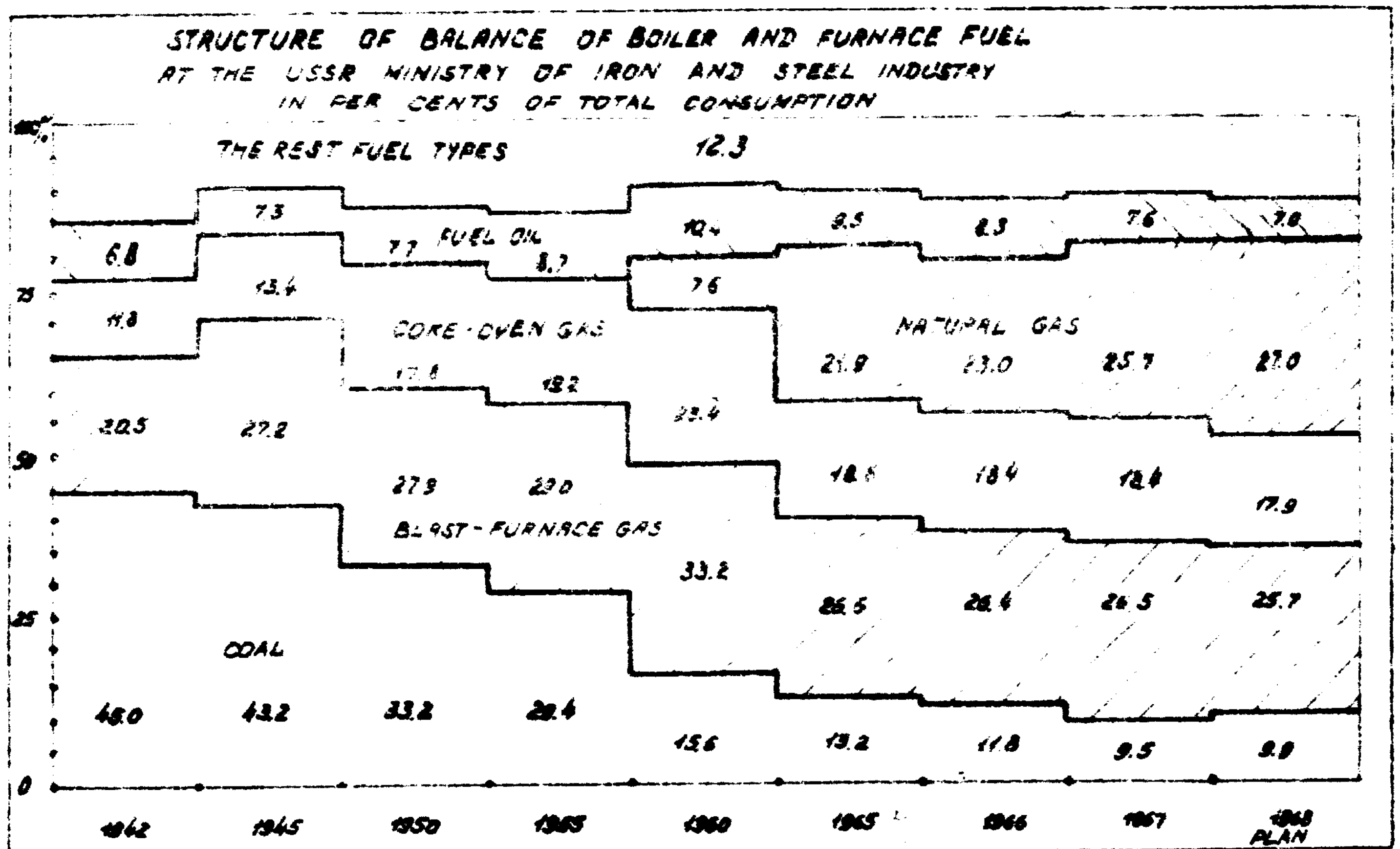

STRUCTURE OF BALANCE OF BOILER AND FURNACE FUEL
AT THE USSR MINISTRY OF IRON AND STEEL INDUSTRY
IN PER CENTS OF TOTAL CONSUMPTION
THE REST FUEL TYPES
FUEL OIL
COKE-OVEN GAS
NATURAL GAS
BLAST-FURNACE GAS
COAL
1942
1945
1950
1955
1960
1965
1966
1967
1968 PLAN

Fig. 1

SPECIFIC FUEL CONSUMPTION
IN KG OF REFERENCE FUEL PER PRODUCTION UNIT

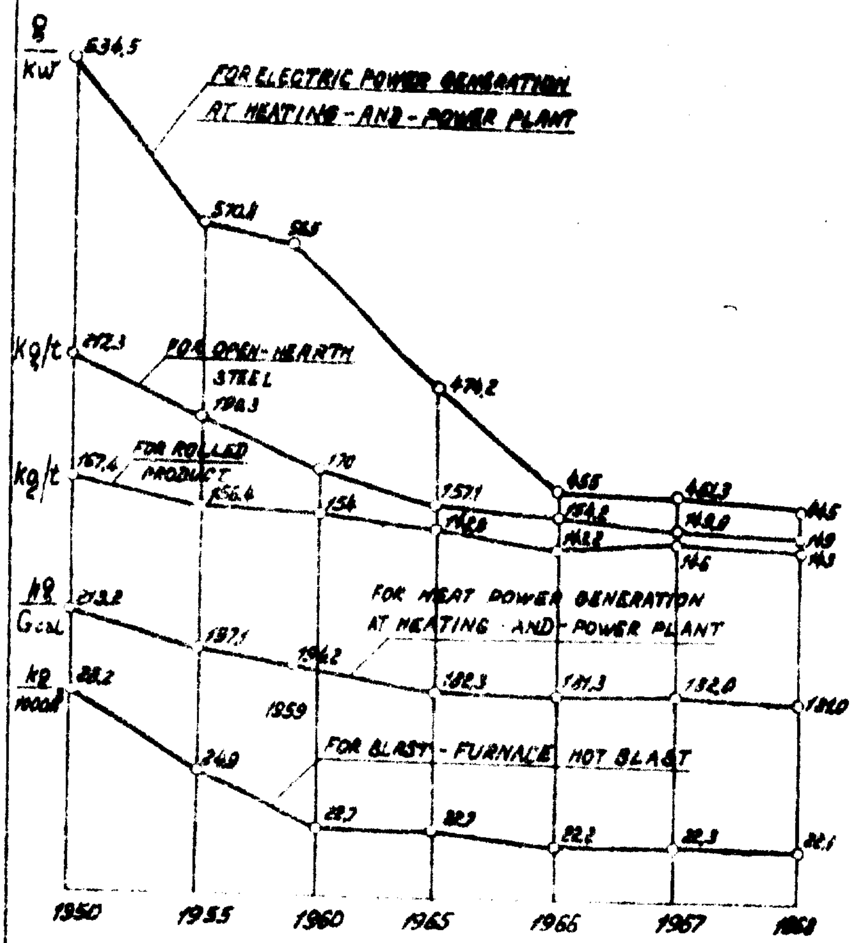


Fig 2

until now were installed.

The installation of new motors and transformation units was often performed using the same foundations on which the electrical machines of smaller capacities had worked. Simultaneously the improvement of automatic control systems for electrical drives using the contactless switches was carried out.

Direct drives with the low speed (up to 25 revs per min.) d.c. motors are used for the auxilary mechanisms (hot shear, manipulators of cogging mills).

Simultaneously with the modernization of electric equipment, the mechanical and technological equipment was reconstructed. As a result of complex measures the output of some units increased two and more times. The output of 1150 mm blooming mill was raised, for instance, to 4.0–4.3 million tons per year.

The present development of electrical drives in the iron and steel industry (blast furnace operation, rolling, tubemaking, wire manufactiring and other production processes) provides for wide use of modern and economic mercury-arc and solid state rectifiers, contactless elements, electronic equipment.

The available power of solid state rectifiers at the works accounts for over 100 MW.

Recently thiristor rectifiers have been introduced for a number of drives. A thiristor electric drive of one of blooming mills in the Ukraine is now under installation; the parameters of the rectifier are 5000 a, 900 V.

The dynamics of electric drive capacity in the iron and steel industry and, consequently, its power providing is determined as follows.

In 1917 the total capacity of electric motors at all metallurgical enterprises amounted to about 200 MW. Presently it comes up to 150–200 MW at one modern shop only. The rated capacity of projected transformer steel shops would account for 440 MW. Presently the total capacity of electric machinery at the enterprises of the iron and steel industry amounts to 22.6 million kW.

The rapid developing the electric-power system of the country, building of powerful district heat-hydro- and nuclear power stations, creation of power system resulted in economic expediency to supply power for metallurgical enterprises from the power pool system while the works power stations should produce power with regard for heat consumption and utilizing by-product fuel (blast-furnace and coke-oven gases, refuse of coking coal cleaning).

If in 1950 power consumption amounted to 63 pct on account of its production at own power stations now it does not exceed 25 pct (Fig. 3).

As a rule enterprises are provided with power from networks operating at 110, 220, 500 kV, sub-stations with transformers of up to 240 MW are extensively used.

Complete distribution installations and transformer sub-stations, sectionalized ordinary busbars, simplified but reliable schemes of protection are used within the works power supply systems. At a number of the iron and steel works automation and centralized control of sub-stations with the use of telemechanization means have been introduced for reliable and economic power supply.

About 10 pct of all power produced in the country is annually consumed by the enterprises of the iron and steel industry. Over the last decade power provision per one person employed in the iron and steel industry increased more than two times; power provision and power supply are continuously increasing.

C. Heat supply.

Increasing the metal production and improving its quality resulted in enlargement of heat energy demand in the form of steam and hot water. This is also contributed by increasing

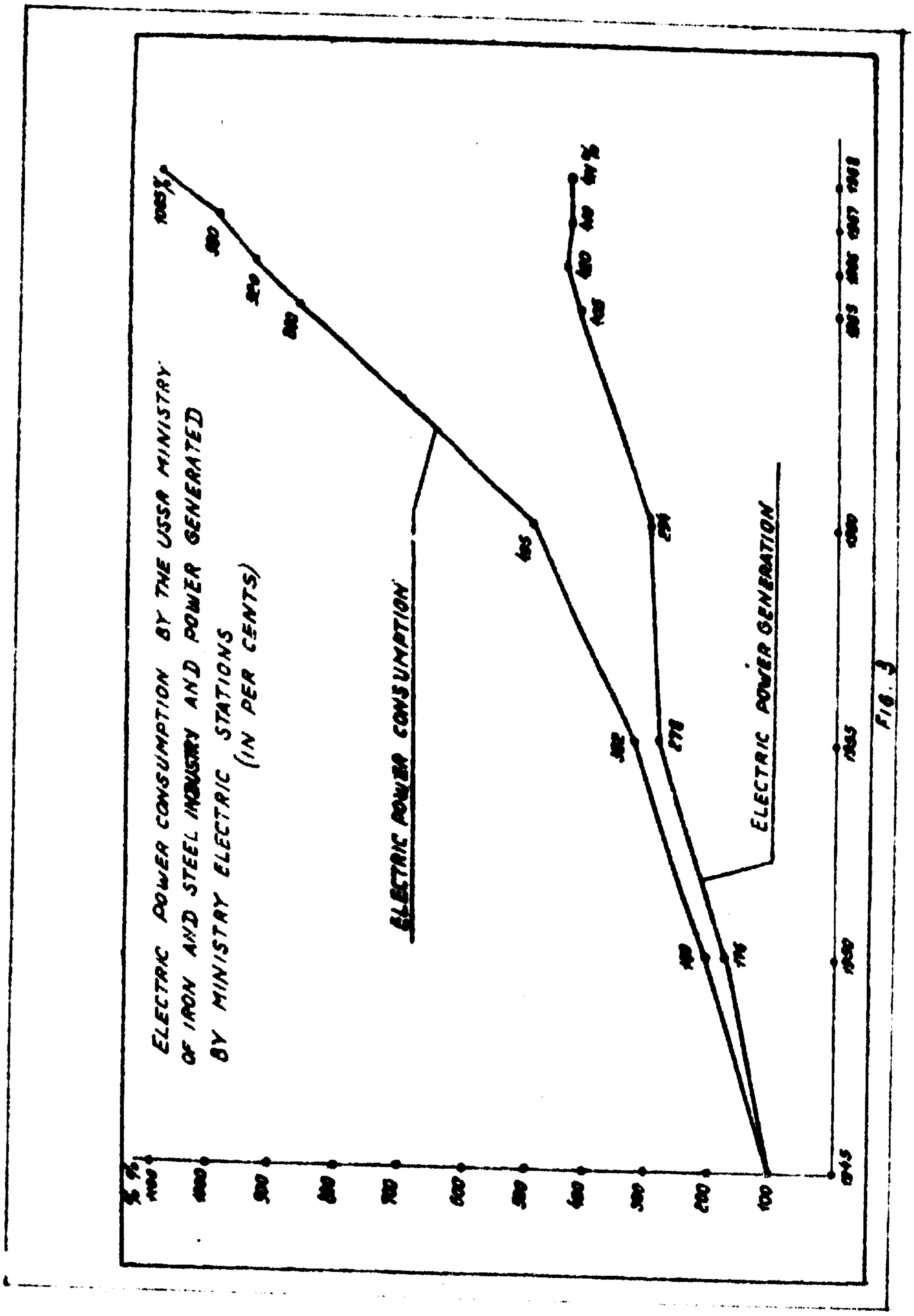

ELECTRIC POWER CONSUMPTION BY THE USSR MINISTRY
OF IRON AND STEEL INDUSTRY AND POWER GENERATED
BY MINISTRY ELECTRIC STATIONS
(IN PER CENTS)
ELECTRIC POWER CONSUMPTION
ELECTRIC POWER GENERATION

FIG. 3

YIELD AND LOSSES OF BLAST-FURNACE GAS
AT THE USSR MINISTRY OF IRON AND STEEL INDUSTRY

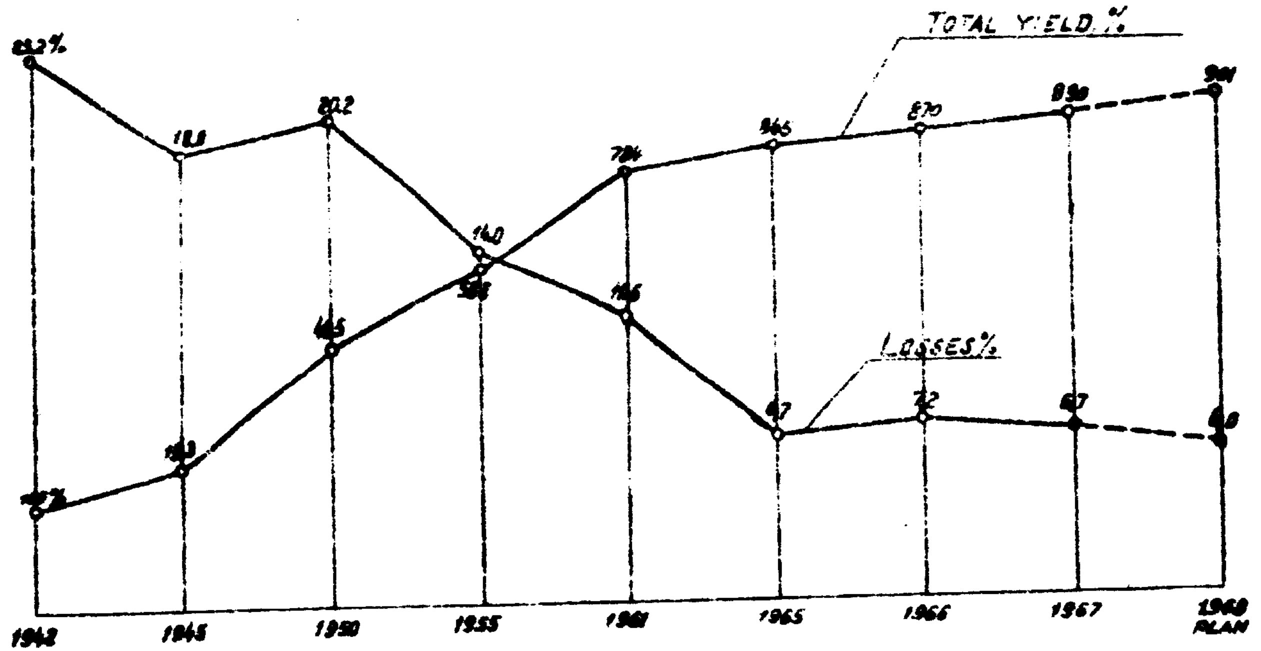


FIG. 4

heat supply for housing of industrial towns and for other industrial enterprises adjacent to the iron and steel works.

Heat energy production at the enterprises (except that to be intended for electric power and compressed air production) increased relative to that of 1950 by 276 pct and in 1967 amounted to 72.2 million Gcal including that of power stations to 37 million Gcal (51 pct), that of by-product energy sources to 17.8 million Gcal (25 pct) and that of industrial boilerhouses to 17.4 million Gcal (24 pct).

D. By-product energy sources.

The present iron and steel industry is not only a large consumer of many kinds of energy but a considerable producer of by-product energy generated due to the isothermal and chemical transformations during the principal metallurgical processes as well as to using the refuse of coking coal cleaning, coke breeze, etc.

Blast-furnace and coke-oven gases, the physical heat of waste gases of different metallurgical furnaces, the heat liberated in cocking high-temperature furnaces and units, the heat of hot coke, the potential energy of top gases of blast furnaces were partly used during many years or were not used at all.

Over last years utilization of by-product energy has been enlarged and would be in progress later on. The Soviet experts in the field of energetics are pioneers in this respect.

If in 1940 the average blast-furnace gas losses at all of the iron and steel works of the country amounted to 23.2 pct of the total output, in 1967 they decreased to 6 pct, i.e. almost four times. In 1950 there were only four waste-heat boilers and now 292 such boilers are in operation producing about 11 million Gcal of heat per year, which results in the economy of more than 2 million tons annually in reference fuel (7000 Kcal per kg).

Waste-heat boilers are installed after open-hearth and reheating furnaces, convertors, roasting furnaces. Steam pressure of waste-heat boilers amounts to 45 atm. abs.; their output accounts for 40 tons of steam per hour.

Fig. 5 shows the KY-100B waste-heat boiler designed to be installed after open-hearth and other heating furnaces. Its principal difference from other types of boilers consists in availability only one vertical gas flue in which all heating surfaces are located. It accupies an area which is two times smaller than usual; this allows to install it under any conditions. The waste-heat boiler may be equipped with shot blasting of heating surfaces. Boiler parameters: pressure up to 45 atm.abs., output up to 20 Gcal per hour.

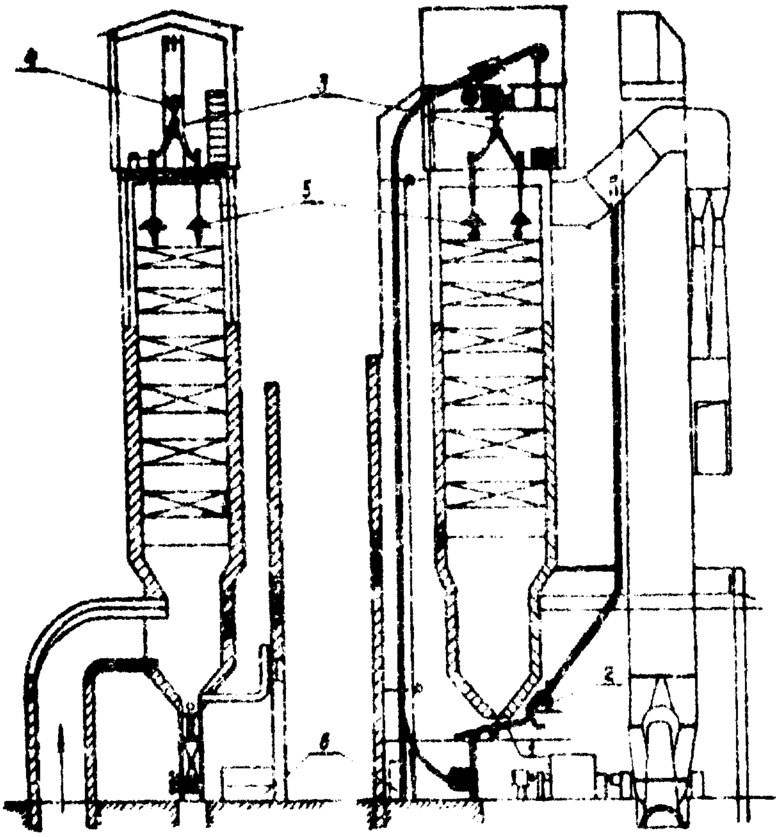
<u>Evaporative cooling of open-hearth furnaces.</u>

The metallic parts of open-hearth furnaces operating under quite heavy temperature conditions are usually cooled by process water the consumption of which amounts to 300–400 cu.m. per hour and more for large furnaces. The heat of cooling water is irretrievably lost in this case.

A new method of open-hearth cooling named "evaporative cooling" was invented in the Soviet Union in 1947 and is extensively used. The drum-separator fed by chemically purified water is installed over an open-hearth furnace. Tubes connected with the lower part of the drum-separator supply the cooling water to caissons, frames and skewbacks of a furnace (Fig. 6). The water partly evaporates in cooled elements and steam-water mixture rises to the upper part of the drum. Steam is separated from the steam-water mixture in the drum; the water recirculates for furnace cooling, the steam goes to consumers.

The application of evaporative cooling allows the water consumption to be decreased 50 times against the water cooling, the life of cooled elements to be raised four or five times and more, the steam produced to be utilized.

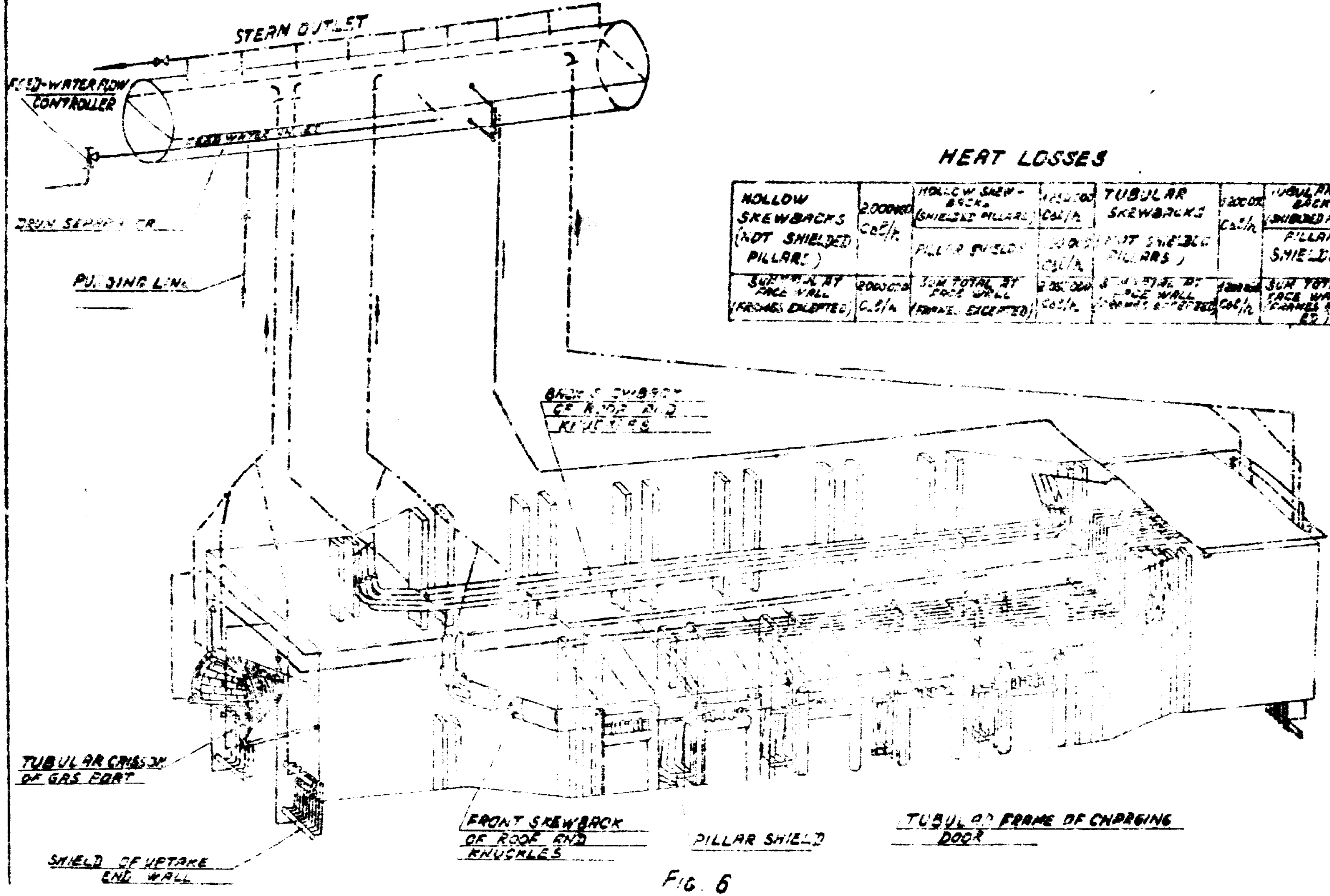
TYPE KY-1006 WASTE-HEAT BOILER
WITH SHOT CLEANING



1 - VIBRATOR; 2 - WINNOWING FAN; 3 - SHOT DISTRIBUTOR;
4 - UPPER BIN; 5 - SHOT SPREADER; 6 - SHOT WASHING TANK

FIG. 5

LAYOUT OF OPEN-HEARTH EVAPORATIVE COOLING INSTALLATION WITH TUBULAR COOLED ELEMENTS



HEAT LOSSES

HOLLOW SKEWBACKS (NOT SHIELDED PILLARS)	2.000000 Cal/h	HOLLOW SKEWBACKS (SHIELDED PILLARS)	[illegible] Cal/h	TUBULAR SKEWBACKS (NOT SHIELDED PILLARS)	[illegible] Cal/h	TUBULAR SKEWBACKS (SHIELDED PILLARS)	[illegible] Cal/h
		PILLAR SHIELDS	[illegible] Cal/h			PILLAR SHIELDS	[illegible] Cal/h
SUM TOTAL AT FACE WALL (FRAMES EXCEPTED)	2000000 Cal/h	SUM TOTAL AT FACE WALL (FRAMES EXCEPTED)	[illegible] Cal/h	SUM TOTAL AT FACE WALL (FRAMES EXCEPTED)	[illegible] Cal/h	SUM TOTAL AT FACE WALL (FRAMES EXCEPTED)	[illegible] Cal/h

FIG. 6

As of January 1, 1967 278 open-hearth furnaces operated with evaporative cooling. In evaporative cooling systems of open-hearth furnaces 7.3 million Gcal of heat were produced in 1966.

Dozens of blast furnaces and heating furnaces of rolling mills have been changed over to the evaporative cooling. The total steam production of cooling installations amounts to more than 12.5 million tons of steam per year, which is equal to 1 million tons of reference fuel. The parameters of a present blast-furnace evaporative cooling installation are: steam pressure up to 40 atm. abs., output up to 40 tons per hour.

It was a considerable achievement in the field of repeated use of fuel to apply the dry quenching coke stations. Until recently coke quenching was carried out with water in open towers. Applying the dry quenching allows .4-.5 tons of steam at the pressure up to 40 atm. abs. per ton of hot coke to be produced.

The nature of this method may be described as follows: hot coke is charged from a car into a quenching tower (Fig. 7) where it is affected by inert gas (nitrogen) blown; heater where its temperature rises to 1000°C due to its partial combustion.

Blast-furnace top gas with that temperature and at the pressure of 2 atm. gauge then enters the exhaust gas turbine where its pressure decreases to .05-.1 atm. gauge. Having been used the blast-furnace gas is directed to consumers through the works gas line. A generator is installed on the shaft of the exhaust-gas turbine. The power produced is supplied to the works power network. It has been calculated that the annual power output of an unit with exhaust-gas turbine may amount to 65 million kWh. The principle scheme of an exhaust-gas turbogenerator is shown in Fig. 8.

By-product energy sources at the iron and steel works are far from being completely used; their utilization is estimated of the order of 25 pct of heat consumed. It is provided that this value should be increased to 30-32 pct in the next 5 years.

The work is being carried on for improving the installations utilizing by-product energy and for their more extensive introducing in the iron and steel industry.

E. Water supply.

The metallurgical enterprises consume large amount of water for cooling some parts of high-temperature production units, power installations, for cleaning and cooling of waste gases, for water descaling and scale flushing at the rolling mills, for hydroasbing, for hydrotransportation and for other purposes.

Presently the iron and steel industry of the USSR annualy consumes more than 14 x 10^9 cu.m. of water.

If until 1950 the water supply of the enterprises was in most cases carried out using the once-through scheme, presently almost all the works use to a great or a small extent recirculation of water which is subjected to purifying, cooling and repeated use at the enterprise. As yet 60 pct of consumed water is used in recirculation cycles.

As the capacities of production and energetic units increase, the requirements to the amount and the quality of water rise. In order to meet these requirements the powerful water supply systems and the water storages with the capacity of 60-600 million cu.m. have been created for the iron and steel works.

To provide water supply for metallurgical enterprises possessing insufficient water resources the scheme of water supply has been developed in connection with the general layout and now 35 water storages with the total capacity of about 1 x 10^9 cu.m. of water have been built, thousands of kilometers of water supply lines have been laid. One of this system is a channel the North Donets-Donbass the length of which is 130 km.

More than 110 million cu.m. of chemically purified water are annualy consumed in the

LAYOUT OF DRY COKE QUENCHING INSTALLATION WITH BOILER

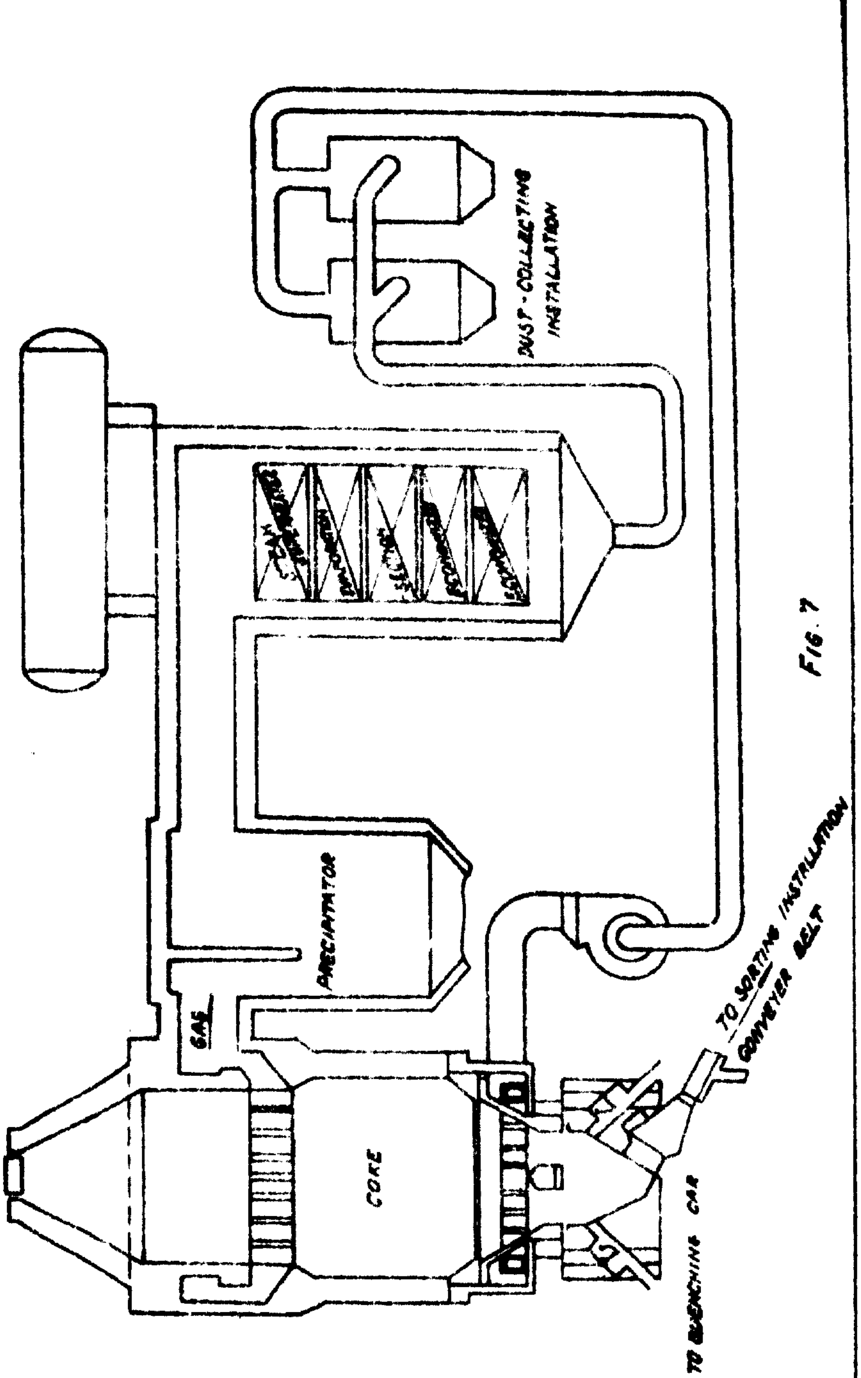
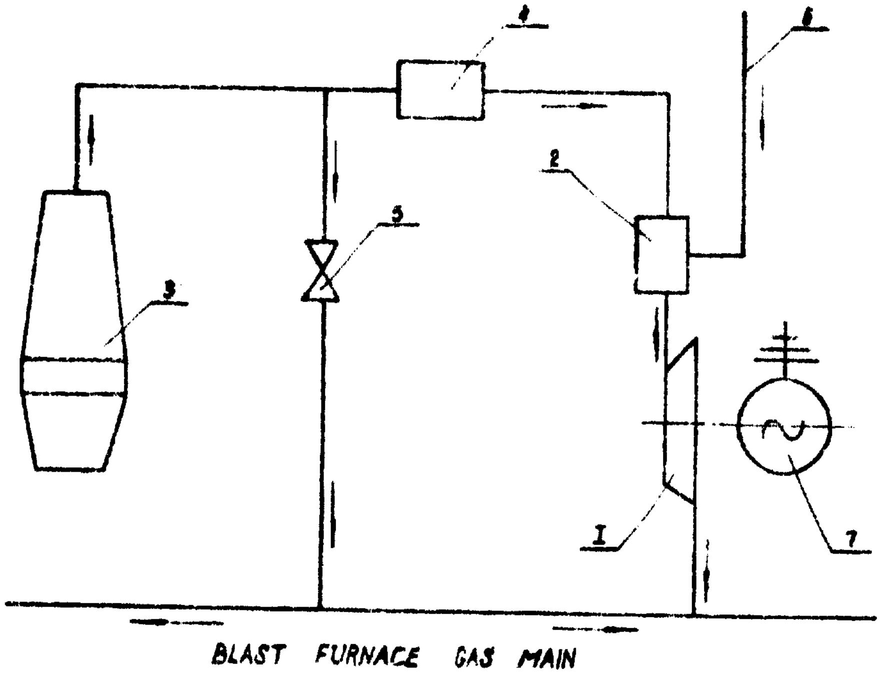


FIG. 7

LAYOUT OF

EXHAUST-GAS TURBINE WITHOUT COMPRESSOR



1 EXHAUST-GAS TURBINE
2 HEATER
3 BLAST FURNACE
4 WET SCRUBBER
5 THROTTLE VALVES
6 BLOWER COMPRESSED AIR TO HEATER
7 ELECTRIC GENERATOR

Fig. 8

iron and steel industry for working of heat power equipment of heat and power stations, industrial boilerhouses, convertor cooling installations, evaporative cooling furnace equipment, etc. The installations for chemical purifying of water with the output of 1000 and more cu.m. of water per hour have been built at the enterprises, the equipment installed depending on the units consuming the purified water.

The feed water for high-pressure boilers is prepared at special plants using the technique of deep desalination of fresh initial water. The thermal systems for purifying the condensate derived from the steam used at production plants are being improved to provide the feed water of the best quality for heating units.

F. Compressed air supply

The metallurgical enterprises consume a considerable amount of compressed air for production and technical needs.

Compressed air at the pressure of 3-5 atm. abs. in amount of 5000 cu.m. per minute is consumed as blast for a blast furnace.

The capacity of such blowers rated to blowing for blast furnaces with the useful volume of 2000-2500 cu.m. amounts to 22-30 MW. An average specific air consumption amounts 2000 cu.m. per cu.m. of blast furnace useful volume. Compressed air at the pressure 7-8 atm.abs. produced at works compressed-air stations is used for technical needs of open-hearth furnaces, for rolling mills and for other technical purposes.

Compressed-air stations are a part of the composition of works. Recently turbocompressors with the capacities of 250, 500 and 1000 cu.m. per hour are installed at compressed-air stations. The output of compressors for air-separation plants amounts to 3000 cu.m. per minute; the capacity of turbodrives comes up to 22 MW. Additionally a large number of coke-oven and blast-furnace gas compressors have been installed for gas supplying the production plants at the compressed-gas and other stations of the iron and steel works.

Power and air-blast stations.

The energy equipment of power and air-blast stations is continuously improved. During the first post-war years boiler units for producing the steam power of 70 atm.abs. were installed at power stations with the liquid slag disposal and turbogenerators with the capacity of 35 MW. At that time turbocompressors for blast-furnace blowing had the output of 3500 cu.m. per minute and turbine drives of 12 MW. The automatic control regulation of some units and assemblies of energy equipment was only being introduced. The further development of the energy economy of the iron and steel industry was carried out using the newest technical achievements. Boilers with the output up to 230 tons per hour and turbogenerators with the capacity up to 60 MW and steam parameters of 110-130 atm. abs., 540-570°C, turbocompressors for blast-furnace blowing with the output of 5000 cu.m. per minute with the turbodrives up to 22 MW output and steam parameters of 100 atm.abs., 540°C, have been installed (Fig. 9).

The total capacity of power and air-blast stations at the enterprises of the iron and steel industry had amounted to about 5.0 million kW by 1968. The capacity of 85.5 pct of total number of power stations is 50-300 MW per each of them. Automation and centralized control of units are introduced at power stations, which considerably increases the reliability and efficiency of their operation.

The heat power demand of enterprises and their housing resources rapidly increases and in 1967 reached more than 77 million of Gcal, 93 pct of the demand is met by their own resources (Fig. 10).

It is envisaged that further development of power stations in the iron and steel indus-

GROWTH OF POWER OF ELECTRIC AND STEAM-BLOWER STATIONS PLANTS AT THE USSR MINISTRY OF IRON AND STEEL INDUSTRY

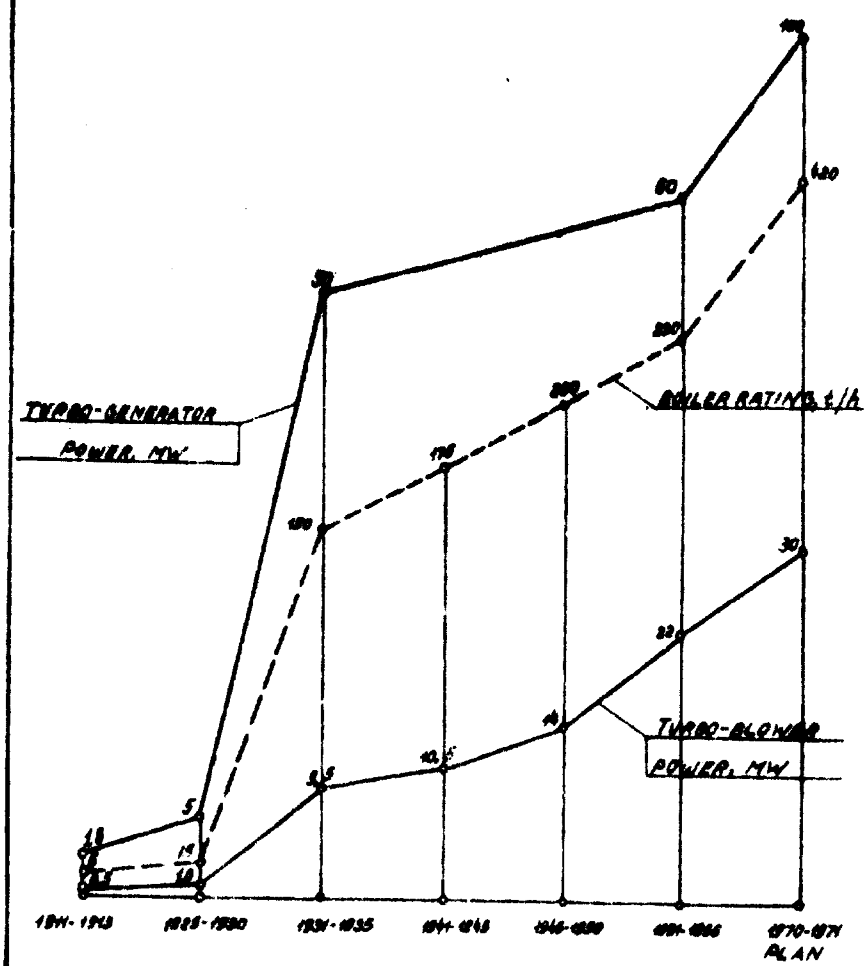


FIG. 9

HEAT POWER CONSUMPTION BY THE USSR MINISTRY OF IRON AND STEEL INDUSTRY
(WITHOUT HEAT POWER SPENT FOR ELECTRIC ENERGY GENERATION AND FOR BLAST-FURNACE BLAST PRODUCTION)
IN GIGACAL × 1000

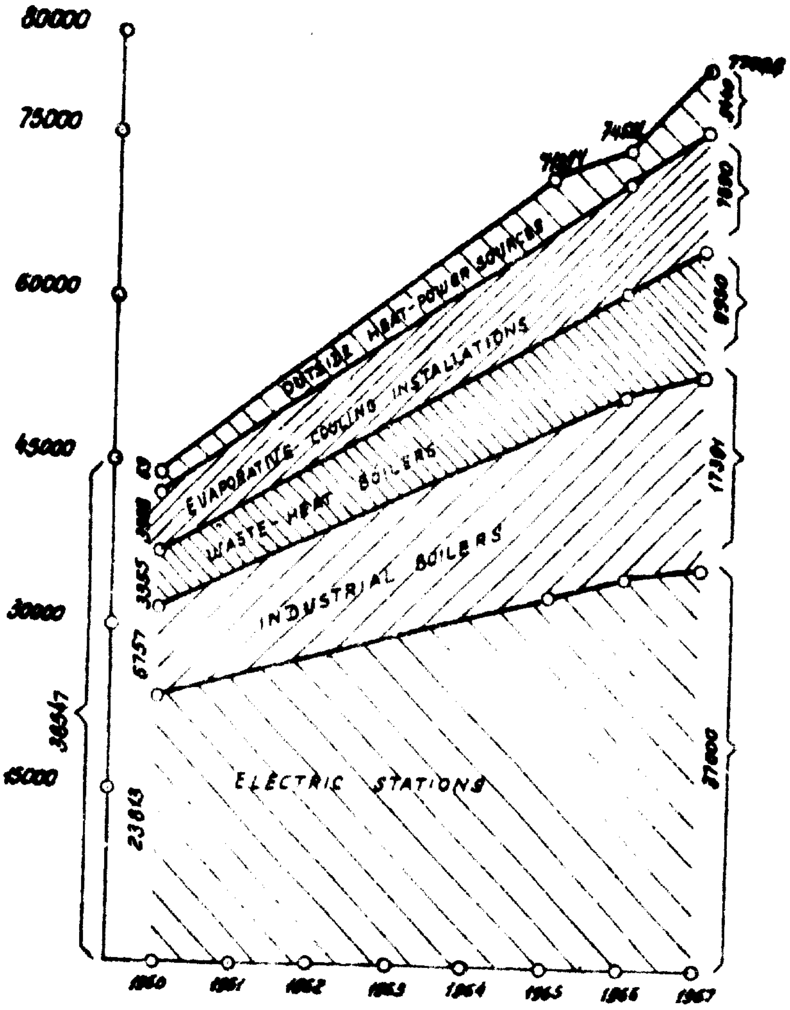


FIG. 10

try should be carried on using the steam of higher parameters (140 atm.abs., 570°C). The heat and power turbines should be installed or the steam take-off for maximal power production when consuming heat should be used.

The fuel balance of works power stations is built up as follows (by heat): gas fuel 77.3 pct including blast-furnace gas 35.2 pct, coke-oven gas 15.7 pct, natural gas 26.3 pct; coal 13.1 pct, intermediate products 7.4 pct, fuel oil 2.2 pct.

About 57 pct of all fuel consumed at power and air-blast stations should be credited to the by-product energy sources of the enterprises.

The power stations of the iron and steel industry provide with electric and heat power the neighbouring housing and industry and contribute to the development of total possibilities of poorly developed areas.

One may cite as an example building the Kuznetsky Metallurgical Combine in Siberia in 1930-1933 where the density of population was equal to less than one person per sq.km., and the nearest town was situated at the distance of over 400 km. Simultaneously a large town and a lot of other enterprises were built there. Presently the population of the town is about 500 thousand of people, there are 5 institutions of higher education, more than 80 secondary schools, theatres, palaces of culture, clubs, libraries, a museum, stadiums, some designing-and research institutes, etc.

Present iron- and steel-making processes and oxygen plant development.

Oxygen is used for intensification of production processes of iron- and steelmaking in metallurgy. The output of air-separation plants increases and their equipment is complicated for the sake of extraction of rare gases-argon, cryptone and xenon.

If prior to 1945 the iron and steel industry had air-separation installations with the output of 15-30 cu.m. per hour for technical needs only, recently the air-separation units with the output of 12,000-35,000 cu.m. per hour began to be installed.

The output of air-separation stations at separate iron and steel works exceeds 110 thousand cu.m. per hour; these stations are a part of energy services of the works.

Air compressors for air-separating units with an output of 35,000 cu.m. per hour are equipped with the turbodrivers with a capacity of 22 MW.

The oxygen production requires considerable amounts of heat or power energy. Increasing the air-separation unit output decreases the specific energy consumption for oxygen production 2-2.5 times versus the oxygen installations operating with the high-pressure air. The blast enriched by 1 pct of oxygen increases the blast furnace output by 2.5 pct on the average and decreases the coke consumption by about 1.5 pct.

In oxygen blowing the bath of an open-hearth furnace its output increases by 10-20 pct and the fuel consumption decreases by 6-15 pct.

In 1967 30.8 million tons of iron and about 52 million tons of steel or 38.5 and 51 pct, respectively, of total production were produced using oxygen. At the same time with the oxygen production the rare gases, argon, xenon and cryptone are produced; they are widely used in the national economy of the country.

Recently nitrogen being a by-product of oxygen production is more and more used as a protective atmosphere in thermal treatment of metal, in fertilizer production, in conservation of heat equipment, etc.

The further intensification of metallurgical production depends in many respects on increasing the oxygen production. Accordingly the building of air-separation units of still more output is planned and the requirement for the oxygen purity (99.7-99.8 pct O_2) is increased, the centralization of oxygen production and distribution and the creation of reserve capacities in the case of peak demand are envisaged.

Automation development.

The automation of separate units and technological processes at the metallurgical enterprises of the country began to be used in 30's only.

The extensive development of automation in the iron and steel industry began in the post-war years. A number of research and designing institutes have been drawn in for the automation studies; the automation services in the form of central laboratories of automation have been established at the metallurgical enterprises. A number of systems and means of automatic checking-up, regulation and control of all metallurgical processes have been developed and introduced.

The application of the means of computing technique and on-line computers in the iron and steel industry was a new stage in the development of automation studies. In this country these studies began developing in the last decade and some positive results have been obtained.

The blast furnaces of this country are presently equipped with the systems of automatic charging of raw materials, with those for stabilization of temperature, and control of humidity, hot blast amount and top gas pressure; thermal conditions of stove heating are automatically controlled.

The system of automatic blast and natural gas distribution among the tuyeres is being introduced. The economic efficiency due to the introduction of these systems results in increasing blast furnace output by 2-4 pct and in decreasing coke consumption by 2.5 pct. The investigations of automatic control of blast-furnace process are carried out using the computing technique. Presently off-line computers operate with blast furnaces of the Dzerzhinsky and Krivorozhstal iron and steel works. Realizing the computer recommendations contributes to the stabilization of blast furnace thermal conditions, provides for coke saving of 10-15 kg per ton of iron and for increasing the output by 1.5-2.5 pct.

The investigations for creating a system of centralized control of blast furnace shop operation are being carried out.

A number of automatic control systems which mainly covers the heat parameters of the process are developed and introduced in open-hearth furnace production. The most effective is a system of automatic control of thermal conditions which embraces the periods of charging, preheating and melting.

The application of this system increases the open-hearth furnace output by 4-6 pct, reduces the specific fuel consumption by 2-4 pct and eliminates the danger of overheating the chequerwork.

A number of elements of technological automation allowing the heat operations to be partly automated have been introduced in the operating oxygen-converter shops. Some premises have been established for introducing the automatic systems with computers to control the oxygen-converter melting.

The operation for automation of electrometallurgy are extensively carried out.

The quick-operating power load regulators using computing installations have been introduced approximately at 20 steelmaking arc-furnaces. An automatic programming-logical system for controlling the arc-furnace operation has been created and introduced.

This system would allow the output of furnaces to be increased by 4.0 pct, the power consumption to be reduced by 5-3.0 pct, the non-metallic inclusion and sulphide content to be lowered.

A system of automatic control of metal level in the moulds of continuous casting plants has been developed and introduced. The system regulates changing the strand withdrawal rate.

Work for automation of strip thickness control has been carried on in rolling production at many works. At a number of the iron and steel works systems of contactless control of main drives and those of the principal mechanisms of cogging mills have been introduced which allows the operation cycle of rolling mills to be reduced by 5-12 pct, the power consumption to be decreased by 3-3.5 pct, the annual saving of an order of 200 thousand rubles per one mill to be provided for.

Ten computers and devices for optimal cutting of billets and bar rolled products have been introduced at the works.

The automatic systems for sheet sorting by thickness and defects have been introduced into industrial operation at the sheet shearing machines of the Magnitogorsky Metallurgical Combine and of the Cherepovets Iron and Steel Works.

In the nearest years the efforts of specialized organizations and enterprises of the iron and steel industry are to be concentrated on the automation work providing the maximal effect for the national economy of the country. This work reffers to the creation of complex automation systems with the use of on-line computers at sintering plants, oxygen convertors, hot and cold strip rolling mills and at other projects as well as of automated systems for operational control of production processes at iron and steel works, tubemaking plants and at mining and beneficiation combines.

Air and water pollution control.

In the recent years a considerable attention is paid to the problems of cleaning the industrial discharges into the atmosphere with the aim of creating a pollution-free air basin at the enterprise.

Cleaning the sintering plant gases not only from dust but from sulphureous compounds represents a difficult problem. The great attention is paid to that problem and there is a hope of a positive solution.

The technical solutions have been found out for waste-gas cleaning of the open-hearth furnaces operating with oxygen injecting. The wet and electrostatic methods of gas cleaning are used. Recently, due to the rise of requirements for the cleanliness of waste gases in hydraulic cleaning the venturi tubes were used, which has improved the quality of gas cleaning and provided the considerable economic effect as against the other methods of cleaning. This method is used for blast-furnace, oxygen-convertor and ferroalloy-furnace gas cleaning.

The wet method with the use of Venturi tubes and the dry method with that of electrostatic precipitators are applied for gas cleaning of open-hearth steelmaking production.

The dry multistage method of fine gas cleaning using the electrostatic precipitators has been applied in the refractory industry.

A new design of gas cleaning installation for arc-furnaces has been prepared.

The gas cleaning installations of present design gave a possibility for decreasing the dust content of blast-furnace gases to 10 mg per cu.m., that of open-hearth gases to 80-100 mg per cu.m., that of ferroalloy-furnace gases to 70 mg per cu.m., and that of oxygen-convertor gases to 100-150 mg per cu.m. However, considerable work is carried out for improving the gas cleaning systems for metallurgical production.

Presently a task is set for complex studying and solving the problem of complete pollution control of air environment at a number of large metallurgical enterprises. To solve this task detailed investigations of unit operations, of qualitative and quantative characteristics of the dust and the chemically harmful impurities are carried on with the help of research institutes. Simultaneously work for improving the technological processes is carried on for reducing the harmful discharges.

A great number of sewage disposal installations have been built and put in operation at the enterprises of the iron and steel industry for waste water cleaning. Horizontal clarifiers are used for purifying scale bearing waste water as well as radial installations for gas cleaning plant water disposal. Acid-containing waste water is treated at neutralization plants. At a number of enterprises the installations for iron vitriol extraction from the waste pickling solutions have been built.

Slime storages accumulating slimes of gas cleaning plants, neutralization installations and other similar plants have been widely used.

Considerable work is planned for further pollution control of the water disposal at the iron and steel industry enterprises.

Organization of maintenance and repairs of energy equipment.

The energy equipment of the iron and steel industry which is intricate in its variety and purposes requires a good organization of maintenance and repairs in order to uninterruptedly provide production units with all kinds of energy and services.

The energy part of present metallurgical enterprises amounts to 25-30 pct of basic production funds. More than 150 thousand people are engaged in the maintenance and repairs of energy equipment at the energy services of the enterprises. The energy equipment maintenance is carried out according to the local instructions developed on the basis of "The Rules of Technical Maintenance of Equipment", "The Rules of the State Mines and Technical Inspection", etc.

The personnel engaged in the maintenance of energy equipment are trained and their knowledge of the equipment, of the rules of operation and instructions is examined.

The running and preventive energy equipment repairs are carried out by the personnel of the shops and enterprises. The overhauls are carried out by the personnel of the enterprises with the help of other specialized organizations. The centralization of repairs is performed for decreasing the cost of overhauls and for improving the quality of work both at the enterprises and in the iron and steel industry as the whole.

Two "Energotchermet" specialized trusts have been established in the iron and steel industry. They have industrial enterprises for organization and performing the centralized repairs of the principal energy equipment and for the engineering supervision of the energy equipment conditions and for the technical assistance to the enterprises.

Outlook of energy equipment development

The Soviet metallurgy has topped the 100-million-ton level of the annual production of steel. The outlook of the further development of the iron and steel industry is still more impressive both in the increase of amount and in the improvement of metal quality.

To provide production with all kinds of energy services and to raise its economy a considerable further improvement of complex and large energy services of the enterprises is planned.

The heat power economy development is projected with the installation of the boilers with the output up to 420 tons of steam per hour rated for the steam pressure up to 140 atm.abs. and the temperature of 570°C, the heat- and power station turbogenerators with the capacity of 100 MW, turbocompressors for blast furnace blowing with the capacity of 30 MW, air-separation units with the output (by oxygen) up to 70 x 10^3 cu.m. per hour. Work for introducing the exhaust-gas turbogenerators and the gas turbines as the drives for turbocompressors is being carried out. Measures for improving the technical level of the principal energy equipment of the enterprises are carried on.

When rating the heat supply of interprises consuming heat in amounts more than 200-300 Gcal per hour thorough techno-economic calculations are carried out to determine whether it is more economic to build heat and power stations or boilerhouses. Heat loads being 400 Gcal per hour and more, the heat supply is as a rule performed from heat and power stations or from the latter and the peak waterheating boilers together.

In the iron and steel industry there is a considerable demand for cold for cooling electrical machinery, ventilation, conditioning-air installations, etc. The low potential heat generated by the utilizing installation of evaporative cooling and others may be used for obtaining cold in special plants. This important problem of the metallurgy begins to be carried out at some works and is to be developed.

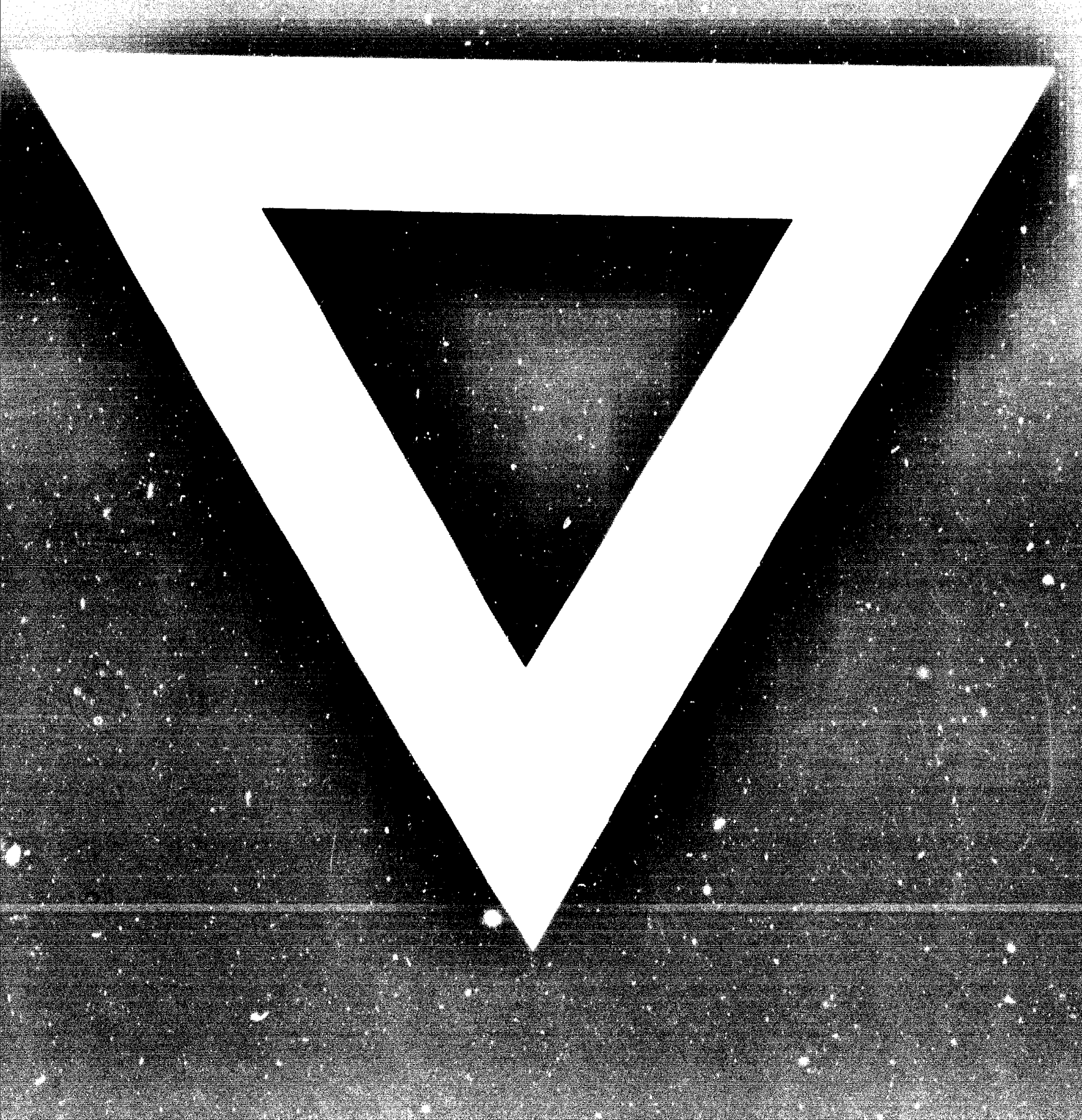
Great work is planned for installing dust- and gas cleaning systems to make the waste gases of metallurgical and energy units will be equipped with more perfect equipment, more reliable and more complete automation, dispatching, communication and television systems.

A number of measures is planned for improving the maintenance and repairs of energy equipment, some trends have been revealed leading to their centralization either in the Ministry of Ferrous Metallurgy of the USSR alone or together with other departments.

Specialized institutes for all aspects of energetics and automation have been established for a systematic improvement of the energy services of the enterprises, developing and introducing the newest and more perfect energy equipment, automation systems and instrumentation, for developing measures for the best utilization of fuel, electric power and by-product energy sources, for air- and water pollution control at the enterprises.

The iron and steel industry has, besides, industrial enterprises in the areas of the Urals, the Ukraine, the Central Asia and the South of the country which accomplish designing the reconstruction and the building of energy installations, starting and setting-up work, investigations and engineering supervision of the energy services of the enterprises.

The available personnel employed at the energy services of the enterprises and in the research- and designing institutes and organizations mentioned above can successfully solve all the problems of the further iron and steel industry development.



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