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28 1 OF 1

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28 June 1979

USSR

# TRANSLATIONS ON USSR RESOURCES
(FOUO 16/79)

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CONTENTS PAGE

ELECTRIC POWER AND POWER EQUIPMENT

Power Machine Building in 1979 Discussed
(V. V. Krotov; ENERGOMASHINOSTROYENIYE, Jan 79) .... 1

Hydroturbine Equipment for Sayano-Shushenskaya GES Described
(G. A. Shishov, et al.; ENERGOMASHINOSTROYENIYE, Jan 79) ..... 8

Modernization of the Hydroturbine Equipment of the Cnirchik GES Cascade
(V. V. Balagurov, M. A. Tsvetkov; ENERGOMASHINOSTROYENIYE, Jan 79) ..... 20

Basic Questions of Designing TETs of Increased Plant Readiness
(V. I. Savin; TEPLOFIKATSIYA SSSR, 1977) ..... 23

FUELS AND RELATED EQUIPMENT

Institute Offers New Principles and Plans for Mine Operation
(A. F. Ostapenko, et al.; UGOL' UKRAINY, Apr 79) ... 42

Tables of 1978 Ukrainian Coal Production
(UGOL' UKRAINY, Apr 79) ..... 52

Bit for Drilling Cement Plugs Described
(S. M. Danelyants, et al.; BURENIYE, Mar 79) ..... 57



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



ELECTRIC POWER AND POWER EQUIPMENT

## POWER MACHINE BUILDING IN 1979 DISCUSSED

Moscow ENERGOMASHINOSTROYENIYE in Russian No 1, Jan 79 pp 1-3

[Article by Minister of the Power Machine Building Industry of the USSR V. V. Krotov]

[Text] The fourth year of the Tenth Five-Year Plan is an important stage along the road toward its successful completion. To achieve this, it is necessary to raise the level of labor organization, and the intensity and pace of work in all labor units of the industry, and to concentrate the efforts and means on the main directions. If in this connection we turn to the goals set for our sector of industry by the "Guidelines for the Development of the National Economy of the USSR for 1976-1980," it is possible to say that most of them are being consistently achieved. Production associations and enterprises of the ministry are achieving the main indexes of the State Plan for Economic and Social Development: the pace of growth, increase of the production volume, and increase in labor productivity. This is expressed concretely in further equipment of domestic electric power engineering, gas industry, and other sectors of the national economy with modern, reliable equipment.

Participating directly in solving the problems posed by the development of the fuel and energy complex of the country, production associations and enterprises of our industry have created a complete set of thermomechanical equipment for an energy unit of 1200 MW which will be installed at Kostromskaya GRES. The first custom-made hydraulic unit of 640 MW for the world's largest Sayano-Shushenskaya GES has been delivered. The production of the second unit is nearing completion. The delivery of equipment for hydroelectric power stations which are under construction in Siberia and in the Far East is also nearing completion: for Ust'-Ilimskay GES and Zeyskaya GES, as well as for the Central Asiatic Nurekskaya GES. Power units have been manufactured for the new blocks of Leningradskaya, Kurskaya, and Chernobyl'skaya AES; equipment of the first unit with a water-moderated water-cooled reactor of 1000 MW which will be installed at Novovoronezhskaya AES.

Designers and technologists of our industry invested much work, creative energy, and knowledge into the creation of this unique unit.



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Our industry participates among other industries in the strengthening of international economic ties of the USSR and makes large deliveries of hydraulic turbine equipment to Canada, Argentina, Brazil, equipment for AES, and other products of the power machine building industry to socialist countries, as well as to other countries developing their national economy.

The technical level and operational reliability of gas-pumping units produced by the enterprises of this industry continues to rise, which is indicated by the fact that one of them, GTK-10-4B, was awarded the State Emblem of Quality. This is the result of the achievements of designers and the further improvement of technological standards, primarily in the production association "Nevskiy zavod" imeni V. I. Lenin.

In the course of the three years of the Tenth Five-Year Plan, our industry has been reconstructing and reequipping the operating enterprises and was steadily increasing the output of power equipment, primarily for atomic electric power stations.

Striving daily for the improvement of effectiveness in this important work, the collectives of associations and enterprises have spread a large-scale socialist competition and concentrated their efforts and creative energy on the fulfillment and overfulfillment of the planned goals. The production association "Krasnyy kotel'shchik" organized a campaign for on-time production and high quality of steam generators and heat-exchange equipment and initiated a competition under the slogan "to work without lagging workers". This initiative of Taganrog boiler manufacturers was supported by the Ministry Board and Presidium of the Central Committee of the industry's trade union, Taganrog city committee and Rostovskaya Oblast committee of the party. On 16 April 1977, "Pravda" newspaper published a letter of the Secretary General of the CPSU Central Committee Comrade L. I. Brezhnev to the workers of the Don area in which he stressed the importance of the campaign "To work without lagging workers" for the country and for the fulfillment of the goals of the national economy. An All-Union conference-seminar was held in Rostov to discuss this effective trend in socialist competitions. It must become one of the guidelines in labor competitions among the collectives of our industry in the fourth year of the Tenth Five-Year Plan in conformity with special characteristics of production and conditions of each enterprise.

Production associations "Leningradskiy metallicheskiy zavod", "Izhorskiy zavod" imeni A. A. Zhdanov, "Turbomotornyy zavod" imeni K. Ye. Voroshilov, and other enterprises formed creative cooperation teams and started a large-scale campaign for economical use of metals and materials, and for improving the effectiveness and quality of labor at each work place.

Those who are introducing the experience of the Leningrad workers based on an integrated solution of organizational and technical problems and on coordination of the actions of all participants of construction projects, from the design to its delivery, can see clearly that the road to the final result becomes considerably shorter when the builders and the deliverers of



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equipment conclude an agreement on socialist cooperation. Such agreements are now used effectively for accelerating the construction of Sayano-Shushenskaya GES and "Atommash" which is known all over the country.

Socialist competitions and the initiatives of the workers of our industry have made a substantial contribution to the fulfillment of the production program of the third year of the Tenth Five-Year Plan, which has opened real possibilities for the fulfillment of the goals with respect to the products list of particularly important power equipment. It is not simple, but possible to achieve this at the present stage of the development of power machine building if we raise the level of production, planning, organization, and clarity in solving technical problems on the basis of close integrated connection of science with production. For this, it is necessary to improve the effectiveness of the work of sectorial scientific and production organizations and institutes, as well as of the design and technological departments of production associations and enterprises.

In 1978, the CPSU Central Committee and the USSR Council of Ministers passed an important resolution on further development of machine building which expanded and concretized the basic ideas contained in the decisions of the 25th CPSU Congress which defined the ways for the improvement of production management and for raising the technical level of power equipment produced by the enterprises of the Ministry of the Power Machine Building Industry. This resolution of the CPSU Central Committee and the Council of Ministers is a new stimulus of our entire practical work in solving the fuel and energy problems on the basis of a wider utilization of the considerable coal resources of the Kansko-Achinsk and Ekibastuz fields and of the not yet exhausted possibilities of the rivers in the central part of the country and the increasing construction of AES and ATETs [atomic heat and electric power stations]. In order to increase the effectiveness of the use of solid fuel of the eastern regions, it is necessary to build highly productive boiler units with new methods of coal burning and achieve an increase in the unit power of units, which promises great savings in metals and operational expenses.

One of the immediate problems of our industry in the Tenth Five-Year Plan is further increase of the output of equipment for atomic electric power stations. To ensure its fulfillment, we must, by the end of the five-year plan, to create complex capacities necessary for the production output in the volumes set by the Guidlines for the Development of the National Economy of the USSR for 1976-1980. The real way of accomplishing this is: acceleration of the pace of construction of "Atommash" and installation of equipment at the prepared construction sites, creation of capacities in the production association "Izhorskiy zavod" imeni A. A. Zhdanov, as well as at a number of other enterprises participating in the production of equipment for AES. The USSR Gosplan has not yet produced such plans for the latter, and this could hinder the development of power engineering and the utilization of capacities already created in the country. In the production association "Izhorskiy zavod" imeni A. A. Zhdanov, in 1979, we must complete the reconstruction of the shop manufacturing hull parts, complete the first section of the forge and press shop, where a 6000-ton-force press must be installed, as well as to start the construction



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of a unit in the shop for manufacturing hull assemblies of reactors. We have to implement additional measures in order to accelerate the manufacturing and the construction of a "5000" sheet mill complex.

At the Kramatorsk Foundry and Forging Plant, it is necessary to accelerate the installation of a press of 15,000 ton-force with manipulators, as well as to speed up the construction of a thermal stripping unit of the shop, and to take all measures for delivering a block of auxiliary shops for operation.

As for the production of equipment for AES, designers, technologists, and production workers, in cooperation with institutes, must accelerate considerably research and design work on individual assemblies of the B-1000 (series) unit, the 1000 MW high-speed turbine, the steam turbine TK-500 for atomic heat and and electric power stations, as well as on an RBMK [expansion unknown] reactor with an electric capacity of one and a half million kilowatt which will be installed at the Ignalinskaya AES.

Hydroelectric power stations are an important part of the fuel and energy balance of the country. During the fourth and fifth years of the Tenth Five-Year Plan, we have to organize the output of equipment for hydroelectric power stations in such a way that the capacities of Sayano-Shushenskaya GES, Nizhnekamskaya GES, and Cheboksarskaya GES would be put into operation on time and that the delivery of the equipment will be completed during the Tenth Five-Year Plan for Ust'-Ilimskaya, Vartsikhskaya, Kurpsayskaya, Ingurskaya, Zeyskaya, and other GES.

For heat and power engineering which is oriented chiefly toward solid fuel of Kansk-Achinsk and Ekibastuz coal fields, the enterprises of our industry must supply in the next few years turbines with a unit power of 500 and, primarily, 800 MW, (small size) boiler units for burning complex ash coal and moist coal of the eastern regions of the country equipped with grinding fans and medium-speed grinders with a capacity of 65-70 tons an hour. At the Troitskaya GRES, studies on steam generators for units of 500 MW under industrial conditions have been completed. It is planned to use them at the new GRES which are under construction in the regions east of the Urals. The obtained data confirmed that the selected design and technological solutions were basically correct, and now we have to perfect the design of these boiler units in the shortest possible time and to organize their series production.

Just as before, one of the most important problems is the problem of uninterrupted supply of heat to the population and enterprises of various sectors of the national economy. The production association "Turbomotor Plant" imeni K. Ye. Voroshilov must continue the production of T-250 turbines for district heating systems in large cities and to set up the production of a turbine of 175 MW as soon as possible.

In the course of the last ten years, our gas industry has become a large-sacle independent industry. Its needs in gas-pumping units have increased and continue to increase. The requirements for their reliability and longeity are increasing. The production associations "Nevskiy Plant" imeni V. I.



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Lenin and "Turbomotor Plant" imeni K. Ye. Voroshilov, who are the main suppliers of equipment for compressor stations, are unable to cope fully with the orders. In 1979, it is necessary to accelerate the implementation of the complex of planned measures for perfecting gas-pumping units with capacities of 6, 16, and 25 MW so as to start their series production at the end of the Tenth Five-Year Plan and the beginning of the Eleventh Five-Year Plan.

Our industry has been entrusted with the solving of another problem which is very important for the national economy: to develop the production of diesel engines for quarry dump trucks and other large trucks. The designers of the production association "Turbomotor Plant" imeni K. Ye. Voroshilov have designed and tested engines ChN6 21/21 and ChN8 21/21. Production workers have to set up their production in the shortest possible time and in the required volume. During the fourth year of the Tenth Five-Year Plan, designers have to create a prototype of the ChN12 21/21 engine. At the same time, it is necessary to complete the construction of a block of special casting shops and to start the construction of a diesel engine production complex planning to put its first section into operation no later than 1980. This will make it possible to start the production of the engines which are necessary for the national economy at the beginning of the next five-year plan.

In the three years, we were able, to a certain degree, to replace our fixed capital, to obtain and install new technological equipment, and to raise the level of production standards and organization. This makes it possible to solve the main problem: to increase the production volume of high-quality power equipment. During the fourth year, our industry will not only continue this important work, but will also strive for its acceleration by all possible means at all enterprises of the industry without exception.

It is also necessary to continue the development and improvement of the facilities for the production of unfinished articles, to use their existing capacities more fully, and to supply rational billets to the industry, which will reduce the consumption of metal and labor input in the production. At the production association "Izhorskiy zavod" imeni A. A. Zhdanov and at the Kramatorsk Casting and Forging Plant, modern equipment was installed for obtaining high-quality steel and alloys of various classes. However, these capacities are not used to the fullest. The main cause is the fact that when designers create new power equipment and modernize the equipment which is in production they rarely use particularly pure metals with higher mechanical properties and service characteristics in their designs.

The associations and enterprises of our industry acquired a large amount of domestic and foreign welding equipment in recent years, however, its adjustment is unjustifiably delayed and it is not used effectively. The quality of welding in the industry still remains to be one of the most important problems, therefore, speedy introduction of new welding equipment will considerably accelerate the production of power equipment and improve its quality.

A large volume of work was done in the three years of the current five-year plan in the area of capital construction. However, a still larger volume of



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work has to be done by the end of the five-year plan. In 1979, it is necessary to accelerate the construction of the second section of "Atommash": buildings 1, 2, 4, and 6, construction center of the general contractor, second plant for large-panel housing construction, and a plant of metal structures. Starting next year, about one million rubles of capital investments must be assimilated daily in the construction of the Volgodonsk Atomic Power Machine Building Plant and the city. It is planned to start the construction of the second plant in Volgodonsk: "Energomash" [power machines].

We hope that there will be substantial improvement in the construction of the branch of the Nevskiy Machine-Building Plant imeni V. I. Lenin in the city of Chudovo, Novgorodskaya Oblast, and its first section will be put into operation in 1980. This will make it possible to increase the output of gas pumping units.

In accordance with the new technical and economic substantiation, the production association "Leningrad Metalworking Plant" has to speed up the reconstruction work in the main area of the plant, and the formation of capacities for the production of the planned number of gas turbines must be completed at the "Northern Site" in 1980.

In production associations "Khar'kov Turbine Plant" imeni S. M. Kirov, "Krasnyy kotel'shchik", Syzran' Turbine-Building Plant, Belgorod and Chekhov power machine building plants, as well as in a number of other enterprises of the industry, simultaneously with the implementation of a complex of organizational and technical measures for the improvement of production, acceleration of its pace, and ensuring the fulfillment of volume indexes in the fourth year of the Tenth Five-Year Plan, it is necessary to assimilate the allotted capital investments and to take all measures to put the planned capacities into operation.

The needs of the national economy of the country in industrial boilers, small-capacity boilers, utilization turbines, as well as in other equipment for industrial power engineering increase every year. Along with increasing the output of these products, it is important to raise their technical level and quality.

One of the main tasks of every work team of our industry in its competition for improving the effectiveness and quality of work in the fourth year of the Tenth Five-Year Plan is economical use of material and technical resources, primarily, metals, electric energy, heat, and fuel. All enterprises must analyze the remaining merchandise and materials and to take concrete and effective measures for their rational and most effective involvement in production. Unfinished production has to be thoroughly analyzed and its potentiality must be used more fully for increasing the output of power equipment.

The collectives of the associations and enterprises of the ministry must, from the very first days of the new year, to spread widely socialist competitions for further implementation of the resolutions of the 25th CPSU Congress and the fulfillment of the State Plan for economic and social development of the



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USSR for 1979 not only with respect to its volume but also in accordance with the products list and agreements, to fulfill the plan for export deliveries, as well as the plan for new equipment.

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ELECTRIC POWER AND POWER EQUIPMENT

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HYDROTURBINE EQUIPMENT FOR SAYANO-SHUSHENSKAYA GES DESCRIBED

Moscow ENERGOMASHINOSTROYENIYE in Russian No 1, Jan 79 pp 4-8

[Article by General Director of the Turbine-Building Production Association "Leningrad Metal Plant" G. A. Shishov, and engineers A. P. Ogurtsov, P. V. Kruglov, O. S. Babanov, S. N. Antonov, V. V. Merkulov, V. N. Khokhulin, and V. S. Slyn'ko]

[Text] In accordance with the decision of the party, the Sayanskiy territorial production complex is being created in the south of Krasnoyarskiy Kray. Its energy basis will be the Sayano-Shushenskaya GES with an installed capacity of 6400 MW. The Sayano-Shushenskaya GES is being built on the Yenisey River in the narrow Karlov Stvor not far from Shushenskoye, the place of V. I. Lenin's Siberian exile.

The Sayano-Shushenskaya GES is the world's largest hydraulic development which is unique in size and complexity. Nine million cubic meters of concrete will be poured into a 245 m high dam. The spillway structures are designed for letting through and suppressing high water flow rates: 13,600 $m^3$/sec. The annual output of electric energy will be 23.5 billion kWh. The hydroturbine equipment for the Sayano-Shushenskaya GES was developed for the following conditions:

| Head in meters: | |
|---|---|
| maximum | 220 |
| rated | 194 |
| minimum | 175 |

A turbine with a rated power of 650 MW, with a wheel diameter $D_1$ = 6.77 m, and rotation frequency n = 142.8 rpm has been developed. Its maximum efficiency is about 96%. At a head of 212 m and higher, the hydroturbine is capable of attaining its maximum power of 735 MW.

According to the design assignment of the Minenergo [Ministry of Power and Electrification], the initial power of the turbine was set at 540 MW.



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The production association of turbine building "Leningrad Metal Plant" examined the possibility and practicality of creating a turbine with a unit capacity of 540-1500 MW for the conditions of the Sayano-Shushenskaya GES. Studies showed the technical possibility of creating a high-power turbine. Power machine builders proposed to equip this GES with turbines of 815 MW. By the complex of the technical and economic indexes of this GES as a whole, it was found that the power of 650 MW was optimal.

It was possible to increase the power of the turbine to 650 MW without changing the dimensions of a 540 MW machine by increasing its speed of operation, which made it possible to reduce the number of units from 12 to 10, to obtain a noticeable economic effect, and to lay out the entire hydraulic development more rationally. In the narrow passage of the GES, in the presence of 12 units, the spillway was located above the GES building, as a result of which there was no reliable suppression of energy of the effluent water. By reducing the number of units, it was possible to place the spillway next to the GES building.

The developed wheels make it possible to begin the operation of the turbines with a head of 120 m. The first two turbines are equipped with replaceable wheels capable of working at the heads of 60-140 m and to develop the power of 150-400 MW. This makes it possible to increase the effectiveness of capital investments by putting the units into operation while the construction of the dam is not yet completed. During the operation of the units with replaceable wheels at the heads of 60-140 m and units with standard wheels at lower heads of 120-175 m, additional 16 billion kWh of electric energy will be produced.

The hydroturbine equipment for the Sayano-Shushenskaya GES developed with consideration for the latest achievements of Soviet and world hydroturbine building on the basis of complex scientific research and technological design studies has marked a new step in the development of Soviet hydroturbine building. Many fundamental design and technological "Sayan" solutions have become basic standard solutions of the association and the industry.

The hydroturbine equipment was created in close cooperation with many institutes, associations, and plants of the Soviet Union and, primarily, with the Gidroproyekt [All-Union Planning, Surveying, and Scientific Research Institute imeni S. Ya. Zhuk], LPI [Leningrad Polytechnic Institute] imeni M. I. Kalinin, VNIIG [All-Union Scientific Research Institute of Hydraulic Engineering] imeni Vedeneyev, TsKTI [Central Scientific Research, Planning, and Design Boiler and Turbine Institute], TsNIITmash [Central Scientific Research Institute of Machinery-Manufacturing Technology], Izhorskiy Plant imeni A. A. Zhdanov, plant "Elektropul't", and many others. In addition to developing hydroturbines, the production association "Leningrad Metal Plant" participates in solving many other problems confronting the builders of the Sayano-Shushenskaya GES.



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Scientific Research

The development of the hydroturbine equipment for the Sayano-Shushenskaya GES, which has no analogues in the world practice of the construction of hydraulic facilities, was a challenging engineering, technical, and scientific problem. Due to the relatively small length of the front of the hydroengineering structures and the 6400 MW power of the station, rigid requirements were imposed on the dimensions of the passage part, which made it necessary to intensify considerably the working process of the hydroturbine. The geological conditions imposed limitations on placing the turbines below the level of the tail water. The problem was also complicated by the fact that the range of heads 170-230 m was not mastered in the domestic hydroturbine manufacturing industry. Moreover, it was planned to put the first units into operation ahead of schedule at a head lowered to 60 m. This required the development of a replaceable wheel for the first priority units and a turbine design making it possible to install two wheels (replaceable and permanant) on the first units.

As a result of the work done by the association in cooperation with the NPO [scientific production organization] of the TsKTI, LPI imeni Kalinin, and VNIIG imeni Vedeneyev, many new wheels were developed whose efficiency level on the model reaches 92.6-92.8%. They have been included in the production list of hydroturbines and can be used at other GES. On the basis of the sum of indexes, the wheel RO 230/833 developed by LMZ whose efficiency is about 96% was accepted. Maximum efficiency of the turbine wheel at Krasnoyarskaya GES is 94%.

A volute chamber with a somewhat narrower inlet section ensuring a high efficiency of the turbine and making it possible to reduce the front of the GES building was developed. The developed draft tube of a height equal to $H = 2.5\ D_1$ maintains a high efficiency level and ensures operational reliability of the turbine.

A large volume of studies was done on the guiding device. Variants differing in the height, profile, and number of vanes and columns of the stator were studied. A guiding device with 20 vanes and 20 columns of the stator was accepted.

Power characteristics on a mismatched guiding device were measured for the first time and the results of these measurements were taken into consideration in designing turbines and the control system for ensuring operational realiability. In order to ensure structural strength, it was necessary to study the stressed state of main parts, primarily, the units of the stator: the volute and the wheel.

Extensive research was done in cooperation with the institutes of the TsNIITmash and LPI imeni Kalinin on the fatigue strength and corrosion-fatigue strength of steels 00Kh12NZD, 10KhSND and MSt 3. This work was done on large specimens at very large bases of loading ($50 \cdot 10^6$ cycles), at various types of loading.



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Parameters determining the kinetics of the growth of cracks in materials were defined for the first time. Studies on the stressed state of the wheel were done through calculations and experimentally. Experimental studies of the stressed state were done on a large cavitation stand of the hydroturbine laboratory. In these studies, both static and dynamic stresses acting in the vanes of the wheel were determined. In order to get more complete ideas of the dynamic state of the structure, the pressure pulsations on the vanes of the wheel were also determined for the first time.

Computations were also done which made it possible to determine the stressed state and to substantiate the "mixed" design of the volute chamber accepted in the project with respect to strength. In the process of complex, theoretical and experimental studies, improvements have been introduced into the theory and practice of hydrodynamic and strength computations, methods of experimental studies were improved, and the experimental facilities were expanded and equipped with modern instruments.

Creation of the Design

Embedded and Fundamental Parts

The weight of the embedded and fundamental parts constitutes approximately 50% of the total weight of radial-axial hydroturbines. In order to manufacture such a unit, it is necessary to have special bending and vertical turning equipment, large plant areas for control assembling, and a large volume of fitting jobs during installation.

The volute chamber and the stator were usually joined along the circumference at a constant height. Such joining required the bending of the volute at that spot in two directions and the stamping of the tore ferrules of welded stators. Stator collars were open, and the links were unfolded manually in a crude way on the loft of the shop, which caused technological difficulties during manufacturing and installation and made it impossible to calculate the unfolding with the aid of electronic computors.

For the Sayanskaya GES, a faceted welded stator of variable height without machining was developed for the first time in the USSR. The stator collars have a box section. The parts of the stator were joined by welding at the GES. The links of the spiral were connected with the stator along straight lines, and the designing and calculation of the unfolding of the links of the spiral and the sectors of the stator were done in an integrated way. As a result of this solution, the precision of the manufacturing improved, the cyclicity of the loads on the volute and the stator decreased, the labor input decreased, and the unique turning equipment became unnecessary. The washed sheets of the stator collars became bent rather then stamped. In order to improve the precision of manufacturing, a program was made for computing the unfolding of the links of the volute and stators with the aid of an electronic computor. This made it possible to build the volute chamber without compensating links.



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All these decisions became standard for any turbines with metallic volute chambers and have been introduced at domestic and foreign GES: Toktogul'skaya, Ust'-Ilimskaya, Zeyskaya, Mica, Capivara, Mactaquac, Site-1. For the first time in the plant practice, the volute chamber for the Sayano-Shushenskaya GES did not go through complete control assembling in the shop. The volute chamber of the Sayano-Shushenskaya GES is unique with respect to the force received from the pressure of water and the force transmitted to the stator. The linear force on the stator of the Krasnoyarskaya GES is 7620 kilogram-force/cm, while this force on the Sayano-Shushenskaya GES stator is 11,000 kilogram-force/cm.

A volute chamber designed similarly to the chamber of the Krasnoyarskaya GES for the conditions of the Sayano-Shushenskaya GES would have the maximum thickness of the scarce alloy steel SK-2 equal to 45 mm. If such a volute is made of carbon steel, the thickness of the shell would be 70 mm. It is simply impossible to make such volutes with the equipment of an association, and is a very complicated organizational and technical problem for a cooperative.

For the Sayano-Shushenskaya GES, the LMZ [Leningrad Metal Plant], in cooperation with "Gidroproyekt" and with active participation of the VNIIG imeni Vedeneyev and NPO of the TsKTI, developed and produced a volute chamber working jointly with one row of the reinforcement of the turbine unit. The casing of the volute is made of the low-alloy steel 10KhSND with a maximum thickness of 40 mm. The reliability of the design of the volute-stator assembly for the turbines of the Sayano-Shushenskaya GES was fully confirmed by tests conducted on large-block models of the VNIIG imeni Vedeneyev.

Thus, the research directed toward the creation of embedded parts for the Sayano-Shushenskaya GES made it possible to solve for any conditions the problem of the creation of stators and volute chambers which fully receive the pressure of water, as well as those working together with the reinforced concrete of the turbine block.

Working Mechanisms and Guiding Device

The hydroturbine equipment was created on the basis of the conditions that turbines with power of 650 MW have dimensions of a block of turbines of 540 MW; a high maximum head of 220 m; the presence of replaceable wheels, a machinery pool at the plant, transportation facilities, as well as with consideration for the modern level of metallurgy.

The guiding device (see Figure 1) is one of the main assemblies determining the arrangement of the entire turbine. The USSR was first to develop a guiding device with individual actuating motors. In order to ensure the necessary power of the turbines with replaceable wheels, it was necessary to increase the aperture of the guiding device by 43% in comparison with the aperatures necessary for working with permanent wheels.



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Figure 1. Guiding Device of the Sayano-Shushenskaya GES

With such large apertures requiring a high-speed operation of actuating motors, normalized kinematics with tightening devices and a regulating ring did not fit in the dimensions of the turbine. The use of individual actuating motors made it possible to improve the configuration of the turbine and create good conditions for servicing its assemblies. Individual actuating motors improved the tightness of the closure of the guiding device and eliminate a breakable part in case a foreign body gets between the vanes. The vanes always remain controllable. The actuating motor serves as a damper of all oscillations of the vanes. The use of individual drives makes it possible to maintain identical opening of all vanes over the entire range of openings. The control system of actuating motors (synchronization) is hydromechanical. The large number of valves and actuating motors made it possible to organize their series production, particularly because the valves and actuating motors for the turbines of the Zagorskaya GAES [pumped-storage electric power plant] are manufactured according to the same designs.

A special axial unloading of the vanes is used in the design of the guiding device, which simplifies considerably the structure of the reception of the vertical force and increases the reliability of the guiding device. At heads of 220 m, the tightness of the closure of the guiding device is very important. Tightness along the joining edges is created by the pull of individual actuating motors, and on the sides -- by special seals. Work was done for the first time on the determination of the necessary pressure in actuating motors during the stressed strained state of the parts, as well as experimental, computation, and design work for studying the behavior of the guiding device during the mismatching of the vanes for ensuring its efficiency and reliability.

The developed design of the guiding device makes it possible to perform large-unit assembling. For this purpose, for the first time in the practice of assembling work, a special traverse with a lifting capacity of 300 tons was developed and used. It makes it possible to transport and lower a fully assembled guiding device. The same traverse carries the wheel and shaft either separately or together.



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Turbine Bearing

For the first time in the world practice, the guide bearing developed for hydroturbines was a rubber, segmental, water-lubricated bearing capable of withstanding a load of 62 tons at a linear speed of the shaft of the order of 15 m/s and a unit pressure of the order of 7 kilogram-force/cm$^2$. By the time of the designing of turbines for the Sayano-Shushenskaya GES, experience had been accumulated in using water-lubricated bearings of the order of 11 m/s and a unit pressure of up to 5 kilogram-force/cm$^2$.

If a guide bearing would be designed by the old norms, its dimensions would be such that it would be impossible to place it within the bearing seat without imparing the operating conditions. The vulcanization of the segments of such a bearing would be a very difficult and new problem for the plants of the mechanical rubber industry.

Scientific-research and experimental-design work demonstrated the efficiency, reliability, and longevity of water-lubricated bearings at a roration speed of the shaft of 15-20 m/s and unit pressures of the order of 7-8 m/s, and their dimensions ensured a good arrangement and technological effectiveness.

Turbine Shaft

Great difficulties had to be surmounted in designing the turbine shaft. On the one hand, a single shaft of the assembly must transmit a tremendous power of 735 MW at a rotation frequency of 142.8 rpm, and, on the other hand, its dimensions were limited by the possibility of manufacturing the face of the thrust bearing of the generator through whose inner opening the shaft flange must go. Another difficulty in the designing was in the fact that the shaft must be used for both replaceable and permanent running wheels.

As a result, a shaft was developed with a tube 1945 mm in diameter with a wall thickness of 275 mm weighing 90 tons. Technologically possible accuracy of the manufacturing of the shaft and the thrust bearing did not ensure the permissible value of the thrust of the shaft. Therefore, the production association "Leningrad Metal Plant" in cooperation with the LEO [expansion unknown] "Elektrosila" imeni S. M. Kirov and All-Union Trust "Spetsgidroenergomontazh" developed a method for centering the shaft of the assembly. A compensating element making it possible to ensure the proper quality of the common trunk of the shaft, which made it possible to eliminate the checking of the common trunk of the shaft by strings in the shops, was added.

Running Wheels

For the Sayano-Shushenskaya GES, it was necessary to create two running wheels (RK) which were entirely different with respect to type and configuration: replaceable runners -- for work at heads of 60-140 m and power of 150-400 MW, and permanent runners -- for work at heads of 175-220 m and power of up to 735 MW.



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The replaceable RK must be inserted in the section between the inlet and the outlet of turbines with permanent RK, and the replacement of the replaceable runners must not be accompanied by the replacement of the main part of the turbines.

As a result of research and technological design work, a replaceable RK of the RO 820a-type (see Figure 2) was developed. The runner of the Capivara GES was taken as the basis, its height was reduced, and the angle of inclination of the lower rim was changed. This made it possible to include them in the section between the inlet and the outlet of turbines with permanent runners, to obtain the characteristics necessary for work at lower heads, and to use the heavy equipment available at the plant with partial alterations (dies, space templates).

Figure 2. Replaceable Runner for Sayano-Shushenskaya GES

Replaceable runners are all-welded carbon-steel wheels with a diameter of 6.05 m weighing 90 tons. In creating RK, the designers proceeded from the requirements of ensuring a high efficiency, optimal configuration of the turbine, technological feasibility, and a rational way of transportation. A special characteristic of the development of permanent RK was the fact that, with their relatively small dimensions, they have to take a tremendous amount of power. There were technological difficulties in creating an all-welded RK because of its small dimensions and a large number of vanes (16).



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

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The RO-230/833-type RK developed by the production association "Leningrad Metal Plant" has high energy and cavitation indexes, has good technological qualities and is strong.

Much work was done by the association to reduce the RK weight. They found the optimal shape of the upper rim which made it possible to increase the overall rigidity of the rim and to move the block bearing of the turbine closer to the center of the application of radial forces on the runner. A solution was found which made it possible to reduce the local rigidity of the upper and the lower rims at the places of conjunction with the outer edge of the vanes by locally thinning the rims, which increases the dynamic strength of the runners. These measures made it possible to reduce the original weight of the RK from 180 to 142 tons. The lowering of the RK weight is also important for its transportation, because this improves the conditions of the loading and unloading operations and makes it easier to navigate the transportation vessel along the Yenisey River. The production association "Leningrad Metal Plant" developed special devices for reloading the runners at the pier of the Krasnoyarskaya GES.

Control and Regulation System

A qualitatively new hydroturbine control and regulation system was created for the Sayano-Shushenskaya GES. It satisfies all modern requirements imposed on automatic control of large hydraulic units. The regulation, control, and signaling system is designed with the use of modern automation elements and facilities.

For the first time, the hydroturbine automation system was based on noncontact logic elements and devices of the unified state series GSP [State Instrument System]. Thyristor stations are used as the starting equipment for electric motors. All this makes it possible to increase substantially the operational reliability of hydraulic units. The design of the guiding device with individual actuating motors made it necessary to develop a special control system for the actuating motors and to change the entire block diagram of the hydromechanical part of the regulation system. The use of a higher oil pressure of 6.3 MPa (63 kilogram-force/cm$^2$) in the regulation system made it necessary to develop a new oil-pressure unit.

The regulation system includes an electrohydraulic regulator of the EGR-2I-10-7-type consisting of two parts. The first part includes an electrical equipment control board, a hydromechanical control column, and a control system for individual actuating motors; the second part includes an oil-pressure unit MNU25-2/63-3 and an automation column for controlling and monitoring all automated elements of the turbine.

The electrical equipment control board is the electrical part of an EGR-GI-type regulator and is based on integrated microcircuits and other highly reliable modern electronic elements. The bulk of these elements are on printed circuit plates which are inserted by means of plug connectors into the units



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of a standard electric equipment control board. The face side of the board has measuring instruments for the visual monitoring of the operation mode of the regulator and the control key. The tuning instruments of the regulator are located on the back side of the board and are covered by a metal door. The control circuit of the automation elements of the regulator is also based on the elements of the series "Logika 1" and is fed from the appropriate supply sources available at the GES.

The control system of individual actuating motors include control valves interconnected by a synchronized transmission, a system of kinematic feedback transmission from each actuating motor, and an intermediate master actuating motor which is the output section of the regulator.

The oil-pressure unit consists of two assemblies: a two-boiler hydraulic accumulator with a capacity of 25 $m^3$ and a oil-pump assembly with three vertical pumps. The three-screw oil pumps pumping 9 l/s were designed especially for the Sayano-Shushenskaya GES. In order to improve the conditions for the operation, monitoring, and tuning of the equipment, a special panel with indicating instruments and individual pump control keys was installed.

Hydroturbine Production Technology and Experience

The high quality of the production of turbines with a simultaneous reduction of labor input and the cycle of their production is a result of the introduction of new solutions for the entire technological cycle. The most substantial and progressive innovations connected with a thorough preparation of production required reequipment and replacement of outdated equipment on the basis of technical and economic analysis done during the development of the turbine design; welded structures constitute 92% of the total mass of the turbine. They include the runner, stator, volute chamber, all ring-shape parts of the guiding device, etc. It became possible to ensure their production at the modern level of requirements as a result of the reequipment of the pattern-cutting and set-up shop. Three fully mechanized lines for producing blanks of rolled steel have been created there and are now functioning. These lines are based on gas-cutting machines with digital program control ensuring a high degree of accuracy of cutting and an overall increase in labor productivity. Edges for welding are prepared simultaneously with the cutting. The machine is operated by one gas-cutter.

For the first time, programs for these machines are developed in a specially created programming center with the use of electronic computers and software. The introduction of the new system increased also the utilization factor of rolled steel. The highly accurate production of sheet billets of unfolded links of the volute chamber in combination with the new system of checking the links after their bending made it possible to eliminate the general control assembling of the unit at the plant which is very labor-consuming and requires a large work area. The assembling of the first two volute chambers at the GES showed that they can be easily assembled.



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The runner is the determining unit in the production of hydroturbines. It is necessary to make two types of runners for the Sayano-Shushenskaya GES: a replaceable and a permanent wheels. Replaceable runners are made of a low-alloy steel. The vanes of these runners are protected against action of cavitation by covering them with thin sheets of stainless steel with the use of highly productive blast welding which ensures a stable quality. This work was done in collaboration with ANITIM [Altay Scientific Research, Planning and Technological Institute of Machinery Manufacture]. During the preparation and development of the new technology, complex technological (parameters of the support, welding process, and subsequent thermal treatment of vanes) and organizational problems were solved. The work was done in field conditions.

Permanent runners are welded from stainless steel OOKh12N3D and are 6.77 m in diameter; the vanes are made of rolled steel by the stamping and bending method. The making of the upper rim of the permanent RK from stainless steel presents a big problem. The upper rim has a diameter of 6.5 m and weighs 72 tons. At the present time, the manufacturing of an all-cast upper rim presents a difficult metallurgical and transportation problem. It was decided to make the upper rim from two parts. The difficulty is also in the fact that the upper rim has a complex configuration and great variations of thicknesses: from 150 to 400 mm.

In order to ensure a high quality of welded assemblies, special attention is given to a wide use of nondestructive inspection procedures.

The metallurgical industry has also solved the problems of manufacturing the vanes of the guiding device from OKh12NDL-brand stainless steel. The use of vertical molding and pouring by the production association "Izhorskiy Plant" considerably improved the quality of the surface and precision of casting.

The most advanced methods (precision casting by the lost-wax process and stamping) have been used at the LMZ for making a number of parts for individual actuating motors and their control system. For the first time in our practice, instead of the combined boring of holes for aligned bolts in the joints of the shaft of the turbine with replaceable runners, they were processed in each individual part separately by a special jig. After appropriate improvements, this technology can become the main procedure at this association.

The new method of making holes for the bearings of the journals of the vanes in the lid of the turbine and in the lower ring of the guiding device with the use of technological rings made it possible to eliminate the cumbersome operation of control assembling of the units in the shop. The coaxiality of the holes is checked by special gauge on parts brought closely together. The new technology not only reduced the labor input in the assembling work and shortened the production cycle, but also increased the accuracy of the mutual arrangement of the bearings of the vane journals.



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The technologists of the association have developed and introduced a complex technology with the use of a large amount of advanced and original special equipment for processing individual actuating motors of the guiding device and their control system. The assembling and testing of the pilot model of the guiding device confirmed the possibility of obtaining the necessary stability of the dimensions in the processing of individual components. The entire complex of technological preparation of production ensured efficient and high-quality production of unique turbines. The blanks of all main components, such as runners, the shaft, vanes of the guiding device, and stator columns, are supplied by the production association "Izhorskiy Plant".

Conclusions

1. The created hydroturbine with a capacity of 650 MW which is capable of attaining the maximum capacity of 735 MW with an efficiency of about 96%, is in line with world's best models and is a new step in the development of the Soviet power machine-building industry.

2. The use of new scientific research methods, technological design solutions, and introduction of new methods of manufacturing made it possible to shorten the creation of hydroturbine equipment by one year.

3. The early completion of the hydroturbine equipment, as well as the use of replaceable runners and other design and assembly methods made it possible to put the first unit into operation two years ahead of schedule while the dam was not yet completed.

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ELECTRIC POWER AND POWER EQUIPMENT

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MODERNIZATION OF THE HYDROTURBINE EQUIPMENT OF THE CHIRCHIK GES CASCADE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 1, Jan 79 pp 31-32

[Article by Engineers V. V. Balagurov and M. A. Tsvetkov]

[Text] The first turbines of the Chirchik GES Cascade were put into industrial operation in 1940. During the last period, the Soviet hydroturbine building industry was developing at a high pace. The large volume of scientific research, experimental, and computation work that was carried out and the use of new constructive, technological, and layout solutions will make it possible to produce highly effective hydroturbine equipment at the modern level corresponding to the IEC [Internationl Electrotechnical Commission] standards. It is characteristic that the unit power of the hydroturbines that are being produced has grown sharply. For example, their power reaches 650-735 MW for the Sayano-Shushenskaya GES. Along with the growth of the capacities that are being introduced, it becomes necessary to modernize the equipment of the operating GES which has been operating for a long time and no longer corresponds to the modern requirements.

The turbine construction production association "Leningrad Metal Plant", in cooperation with the Minenergo [Ministry of Power and Electrification] of the Uzbek SSR have done a great deal of work on the modernization and reconstruction of the hydroturbine equipment of the Chirchik GES Cascade. The following have been designed, manufactured, and installed: two cast running wheels (RK) 300 cm in diameter (Tavakskaya GES) and 305 cm in diameter (Chirchik GES imeni F. G. Loginov) for radial-axial-type (RO) turbines of 23 MW each, four sets of segmented guide bearings of a water-lubricated turbine, four sets of speed regulators of RM-type hydroturbines. Bushings of the vane turning mechanism of the guiding device (NA) made of a new antifriction self-lubricating material were introduced for the first time at the hydroelectric power stations of Central Asia.

The bushings of the vane turning mechanism of the NA are designed in the form of a layer of an antifriction glass-epoxy material applied to steel casings by a special process. The new material works well without lubrication due to its antifrictional properties, is wear-resistant, is water and oil resistant, and has a low coefficient of friction. Moreover, the permissible unit pressures are 25% higher than for bronze bushings. In order to reduce



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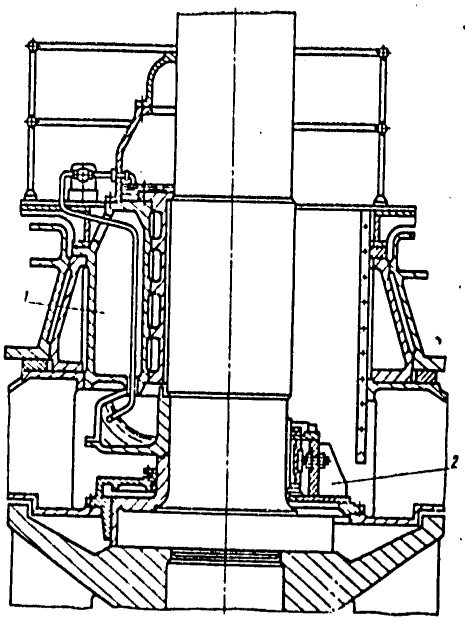
friction in the supporting assembly, the journals of the guiding vanes are faced with stainless sheet steel.

Inspection and measurement of bushings made of the new material conducted on Unit No 4 of the Chirchik GES which worked for 4636 hours in a generating mode showed that the diameters of the bushings remained almost unchanged and their surfaces did not have any signs of wear, such as tear-out or scratching. The use of the new antifriction material in the bushings of the guide vane turning mechanism simplified the design considerably, increased the reliability and longevity of the friction assemblies, and made it possible to eliminate the system of centralized grease lubrication. This saved up to 1000 kg of high-quality bronze and 300 kg of grease lubricant per year for each unit.




Turbine Guide Bearing:
1 -- babbit on a liquid lubricant;
2 -- with rubberized segments, water-lubricated

The new RK whose vanes are faced with stainless sheet steel in order to avoid cavitational erosion have higher energy, cavitational, and operational characterics. The part of the RK between the inlet and outlet ensures a high efficiency of the turbine. The creation of two RK which combine well with the remaining permanent assemblies made it possible to install them in the process



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of major overhauling. The holes in the turbine shaft -- RK flange joint were bored with a portable machine followed by their honing with fine-grain bars. Newly made bolts were ground at the GES according to the actual dimensions of the holes.

The replacement of babbit bearings with liquid oil lubrication by water-lubricated segmented rubber bearings made it possible to simplify considerably the design of this supporting assembly of the rotor of the hydraulic unit: it became unnecessary to have the upper fixed oil bath and the lower rotating oil bath, a gear-type pump, and the hardly accessible stuffing-box seal situated under the bearing. The installation of a new guide bearing with rubberized segments over the RK reduced the consol-type characteristic of the latter, improved the vibration state of the hydraulic unit, and made it possible to lower considerably the station-wide consumption of turbine oil and expenses on its purification and regeneration (see Figure). It is becoming very important to eliminate completely the oil contamination from the lubrication system of the bearing of the tail water (NB) which is the source of water supply to the population of the cities of Tashkent and Chirchik.

The technology of the manufacturing of the shaft jacket from stainless steel sheets ensures a high quality of its assembling and welding directly on the unit without subsequent thermal and mechanical processing.

The new design of the guide bearing made its servicing easier and increased the reliability, longevity, and repairability of the assembly. As a result of the tests conducted on unit No 3 of the Chirchik GES, the minimum consumption of water for lubrication and cooling of the segmented bearing was determined to be 0.5 l/s at which the turbine has been successfully operated since January 1977. The water temperature gradient at the inlet and discharge does not exceed 2-5 degrees C.

The RM-100-2-type regulator (mechanical regulator with the diameter of the main valve of 100 mm) is intended for controling a radial-axial hydroturbine. It automatically starts and stops the unit from a remote command pulse, as well as performs emergency shutdown of the turbine under the effect of safety devices provided for in the automatic circuits. The regulator makes it possible to control the turbine manually directly at the hydromechanical control column.

The use of the RM-type regulators made it possible to maintain stable synchronous rotation frequency automatically, accelerated the control processes, increased the output of electric energy, improved the reliability of the work of the units, and simplified their operation. The installation of the new regulators simultaneously with increasing the technical and operational characteristics improved the appearance of the energy equipment in the machine room.

Thus, the modernization and reconstruction of outdated and worn-out equipment at the operating GES are technically and economically practical and will considerably increase the effectiveness of the operating electric power plant.

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ELECTRIC POWER AND POWER EQUIPMENT

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BASIC QUESTIONS OF DESIGNING TETS OF INCREASED PLANT READINESS

Moscow TEPLOFIKATSIYA SSSR in Russian 1977 pp 67-83

[Article by V. I. Savin (VNIPIenergoprom)]

[Text] To provide for the increasing rate of putting TETs capacities in operation, it is necessary to solve a complex of problems in designing and organizing plant manufacture of basic and auxiliary equipment, pipelines and building structures and improving construction-installation work.

The development of a typical series design of a gas-fuel oil TETs of increased plant readiness (TETs-ZIGM) by the VNIPIenergoprom* collective was the beginning of the work on the solution of the posed problems.

Inasmuch as the most promising initial steam pressure for the industrial-heating TETs in the very near future will be 13.0MPa (130 kg-force/cm$^2$), this initial parameter was adopted for a typical design.

Domestic power building as a whole is characterized by the wide use of typical designs. The first typical designs of 24Mw main TETs buildings with boilers of 60/75 and 90/110 tons/hour boilers (1949), and a 50Mw standardized main building of a TETs of four typical (1952-1954); a typical design for the TETs-350 with boiler steam parameters of 14.0Pa (140 kg-force/cm$^2$) and 570°C (1957); design TETs-350-U (1959); universal design of TETs with 50 and 100 Mw turbines and from 320 to 480 tons/hour boilers when operating on various kinds of fuel; and a typical TETs-68 design. The Promenergoproyekt (now the VNIPIenergoprom) developed typical designs of main buildings of TETs as follows: in 1950-1963 -- a series of TETs-12, TETs-24 and TETs-50 typical designs; in 1963-1966 -- a universal design of a main building of TETs with 12 to 60Mw type PT, PR, T and R

*The following also participated in the design development: the Orgenenergostroy, Energomontazhproyekt, the Proyektstal'konstruktsiya institutes; the Barnaul' and Belgorod boiler plants; the Leningrad Metal Plant, the Ural Turbine-Motor Plant and other organizations.



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turbines and 120 to 420 tons/hour steam boilers; in 1969 -- a typical TETs-300 design in five versions for solid and gas-fuel oil fuels with 50 to 100Mw turbines and 420 tons/hour boilers. The use of typical designs reduced the time for providing construction sites with design-estimating documentation and made it possible to utilize the achievements of science and engineering more fully. However, for a number of reasons, such designs did find comprehensive universal application.

Industrial-heating TETs are characterized by a variety of initial conditions with respect to the absolute values of heat and electric loads, as well as with respect to heat carriers in the form of hot water and superheated steam with various parameters. Therefore, it is practically impossible to execute a single comprehensive typical design of a TETs with a certain set of equipment.

On that basis, in the design of a TETs-21GM, a principle of an individual approach to each element of the complex was used, which was to be designed observing requirements of a standard calculated to be utilized many times for many years.

In such an approach, instead of a typical design for the main building as a whole, designs are developed of individual constant members of the main building which, in a certain combination, make up the given main building. This changes the technology of the TETs design radically.

According to the new technology, the design of a series TETs consists of structurally developed drawings of coded construction-technological sections, units or blocks which may be intercombined in various ways which, when applied to a concrete facility, form the necessary complex of working drawings for its construction.

The following conditions are observed when designing such standard elements: a detailed design must be developed that provides efficient plant and installation technology ; the possibility of series production of a single type of elements, units and blocks; the elimination of the one-time manufacture of a large number of elements from drawings of the design organization on the construction site; a considerable reduction in finishing and fitting work in the process of construction and installation; the possibility of series manufacture of elements and units for warehouses for complete sets of parts; a radical change in the nature of construction-installation work by changing over basically to assembly installation; and a reduction in the technical documentation received at the construction site.

Standardization of designs. To standardize the structures and units used it is necessary, first of all, to reduce the number of basic technological equipment used in the project.



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As a result of an analysis made by the VNIPenergoprom of the state of this problem, taking into account the practice of the past years and the prospects up to 1980, it was established that there are seven types of turbines with steam parameters of 13MPa and 565°C [PT-60 (PT-80), PT-135, P-50, P-100, P-110 and T-175] recommended for use up to 1980, based on multi-version combinations in steam and water requirements. As far as using boiler units is concerned, in the majority of cases, it is possible to limit oneself to one type of boiler with a productivity of 420 to 450 tons/hour and a pressure of 14MPa.

This opened up the possibility of standardizing a wide range of designs for the main building of series built TETs, inasmuch as such a large component of the main building design as boiler facilities was a constant element within the design of the series built TETs independently of the set of turbine equipment.

The entire main building was divided into individual elements with a comprehensive analysis being made of each element for determining its application to any set of basic equipment.

Such an analysis indicated the feasibility of creating structural-technological sections for the main building of a single type-size in the form of a modular size of a boiler cell of 24m (12.0 x 2m) and a grouping of the T-100-120-130-3 turbogenerator coordinated with the Ural Turbomotor Plant, which made it possible to reduce the machinery hall cell from 36.0 to 24.0m and the bay -- from 42.0 to 39.0m, with the transfer of circulation and network pumps that do not require high buildings to less expensive housing for the circulation and network pumps. Such a bay of the machinery hall (39.0m) is also preserved for T-175, PT-135 and R-100 turbines.

On the basis of these solutions, the main TETs building can be made up of the following comprehensive construction-technological sections: (turbine + boiler) -- single section 12.0 x 2 = 24.0m; (turbine + 2 boilers) -- double section 2(12.0 x 2) = 48.0m, with one BKA-420/450 boiler installed with PT-60(PT-80), T-100 and R-50 turbines and two BKZ-420/450 boilers each installed with PT-135, R-100 and T-175 turbines.

Besides these sections, the main building must include, for all cases of newly built TETs, a "constant end" section in which are located such general-plant technological equipment and services as the central electric switchboard, storage batteries, pumps for the acid washing of boilers, RVV [Excitation switch-on relay] for slime waters, lighting RUU [Pressure-reducing and cooling unit], vacuum deaerators, equipment for preheating rain water, network water for radiators, shops, etc., as well as sites for locating equipment during capital repairs.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



Besides basis equipment , boilers and turbines, typical boiler-turbine sections will also have auxiliary equipment that will insure fully the viability of the given boiler-turbine section, taking into account the equipment installed in the "constant end" section and other structures located in the TETs area (circulating pump facility, the OVK [Combined auxiliary building] , fuel oil storage, etc.).

The auxiliary-general-plant equipment located in the "constant end" section insures the operation of the TETs by producing for its own needs and industrial pruposes steam of two parameters -- with pressures of 1 and 1.5MPa (10 and 15 kg-force/cm$^2$) in an amount of up to 1100 tons/hour and hot water up to 5028 gigajoules/hour (1200 gigacalories/hour).

When it is necessary to increase the steam output for industrial purposes, additional equipment is installed in a so-called "final gathering" section. If not all auxiliary equipment, specified for a typical design of a "constant end" section, is needed, only part of that equipment is installed and this does not affect the arrangement of the remaining equipment and pipelines and does not require the preparation of new drawings.

Thus, the "constant end" section is the constant large element within the main building.

On the open site near the "constant end" section are located vats for preparing washing water for the RVP [Pneumatic timing relay] and gathering it after washing, vats for gathering clean and oily waters from the bearings of machines in the main building with a group of pumps. Since this general-plant equipment practically does not change with the capacity of the TETs, this element is also constant.

For each construction-installation section of the machinery hall, the drawings of the thermo-mechanical equipment, electric equipment, automatic control-system, KIP [Control and measuring instruments] , as well as the construction drawing of the underground facilities are based on the type of the turbogenerator used in that section.

Designs of a temporary end and final gathering section were developed for providing a normal technology of the construction-installation work and repairs of equipment and operation in the section of the main building.

The temporary end section provides the possibility of industrial large-block installation of thermomechanical equipment in the terminal technological section spreading out the equipment during repairs and the repairs of transformers. The section includes mobile temporary ends of the machine and boiler departments, inlets of RR tracks into these departments (combined with tracks for moving transformers).



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



The construction structures of the temporary end are similar to the structures of the technological section, which makes it possible, when expanding the TETs further, to utilize the temporary end section as part of the technological section or as a final gathering section.

When the TETs has more than four boiler-turbine section, a final gathering section is installed beyond the fourth section, which provides for spreading the equipment during capital repairs.

Also located in the final gathering section are additional members of general-plant equipment which cannot be located in the TETs with thermal loads of over 1100 tons of steam per hour for a load of hot water of 5028 gigajoules/hour (1200 gigacalories/hour).

Thus, the main building, taking into account the assumed basic equipment, consists of the following comprehensive construction technical sections:

A. Sections -- size 12 x 2 = 24.0m;
section -- "constant end;"
section -- PT-60 (PT-80) with one boiler;
section -- T-110 with one boiler;
section -- R-50 with one boiler.

B. Sections -- 12 x 4 = 48.0m:
section -- PT-135 with two boilers;
section -- R-100 with two boilers;
section -- T-175 with two boilers.

C. Sections -- 12.0 x 1 = 12.0m:
section -- "constant end;"
section -- final gathering.

A main TETs building satisfying any given conditions of a concrete facility can be "assembled" in any sequence from such standard construction-technological sections.

A thermal arrangement with transverse ties was adopted in the design. Based on the sectional principle, the thermal arrangements were developed for each section individually so that the thermal arrangements of the sections can be used without additional changes to make up a thermal arrangement of the electric plant with any set of basic equipment adopted in the design.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



As the basis of developing thermal arrangements of placing all general-plant equipment and pipelines in the "constant end" section, the principle of locating only auxiliary equipment for servicing basic pipeline connections between boilers and turbines and adjacent sections in boiler-turbine sections was adopted.

As a result, in preparing the general developed thermal system of a concrete TETs, it is necessary only to assemble it (and not develop it) with previously developed thermal arrangements of construction-technological sections in a sequence and a set of basic technological equipment which corresponds to a concrete TETs being designed.

The design of the main building with all its parts is thus reduced to preparing plans listing the types of construction-installation sections, a set of working drawings corresponding to a concrete facility, specifications and estimates developed in the design of a series built TETs and tying-in the foundations to local conditions.

Fig. 1 shows arrangements of construction-technological sections, an example of assembling a main building from such sections and plans of main buildings of concrete stations which are being built at present or will be built in accordance with the series TETs-ZIGM design.

As may be seen from these pictures, the main building of all of these plants were "assembled" from the above-indicated standard sections.

In cases where large elements of the design could not be used in an unchanged form, modifications of these elements were determined and developed, if they did not call for radical changes.

As an example of such modification, a deaeration shelf may serve for which working drawings for construction-technological sections PT-60 and T-110 may be used by 80 to 90%, while the volume of modification (i.e., the number of working drawings being changed) does not exceed 10 to 20% respectively.

In case it is not possible or feasible to modify elements of the design), other versions were developed in the required amount. This applies, in particular, to elements of the main electric circuit, since conditions for the distribution of electric power are dictated by local conditions. The elements of the main circuit and working drawings are made in three versions:



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



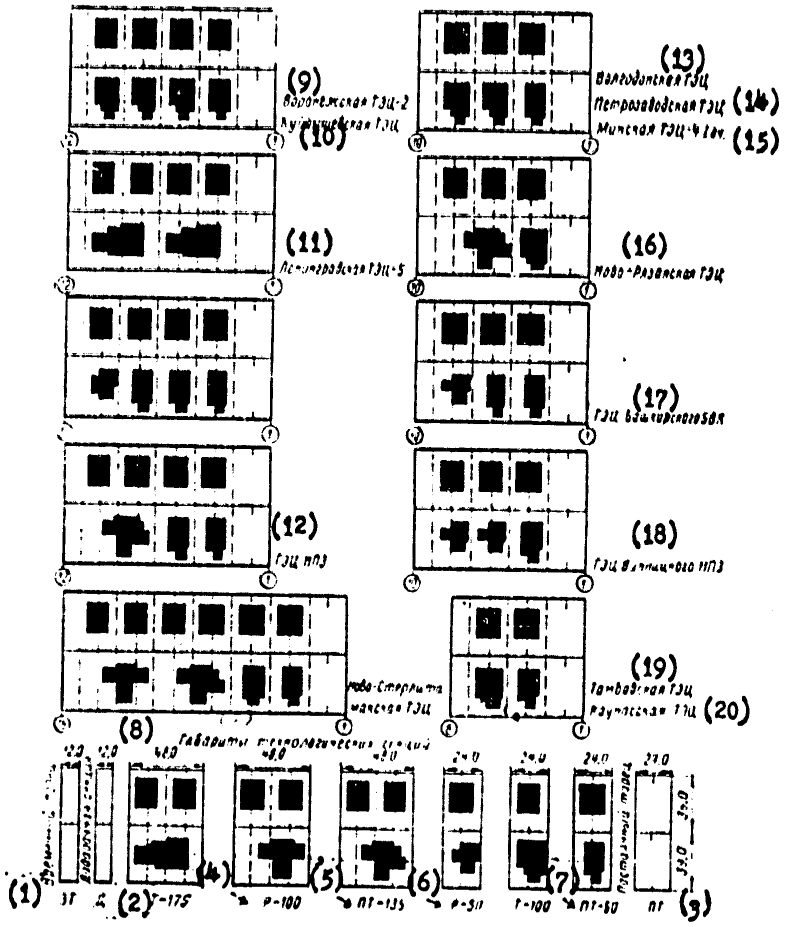


Fig. 1. Examples of arrangements of main buildings of TETs-ZIGM by assembly of sections.

Key on the following page.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



Key to Fig. 1 on previous page.

1. VT -- temporary end
2. D -- final gathering section
3. PT -- constant end
4. -- R-100
5. PT-135
6. R-50
7. PT-50
8. Sizes of technological sections
9. Voronezhskaya TETs-2
10. Kuybyshevskaya TETs
11. Leningradskaya TETs-5
12. TETs-NPZ [Petroleum processing plant]
13. Volgodanskaya TETs
14. Petrozavodskaya TETs
15. Minskaya TETs-4, first stage
16. Novo-Ryazanskaya TETs
17. Bashkirskaya BVK [expansion unknown] TETs
18. TETs Vinnitskiy NPZ
19. Tambovskaya TETs
20. Kaunasskaya TETs

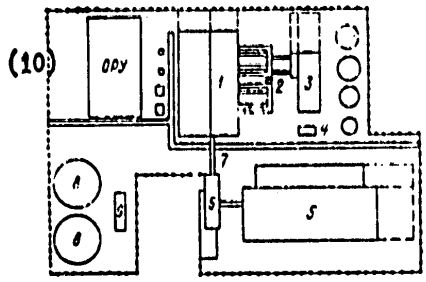


Fig. 2. Arrangement of general plan of TETs-ZIGM.

1. main building
2. smokestack
3. water-heating boiler
4. gas-distrubution center
5. combined auxiliary building (OVK)
6. general service building
7. overhead bridge
8. cooling tower
9. pumping station for circulating water supply
10. ORU [Outdoor distribution system]



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



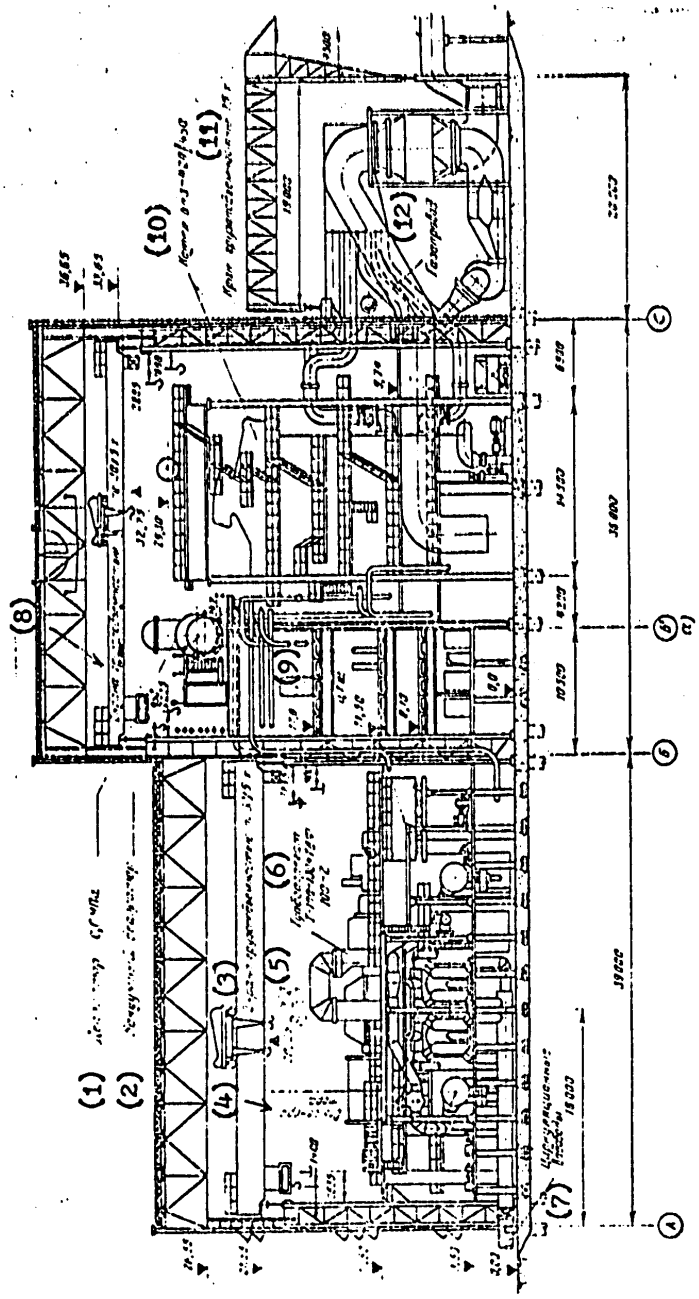


Fig. 3. Arrangement of equipment in main building of the TEPs-ZIGM.

a -- transverse cross section



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

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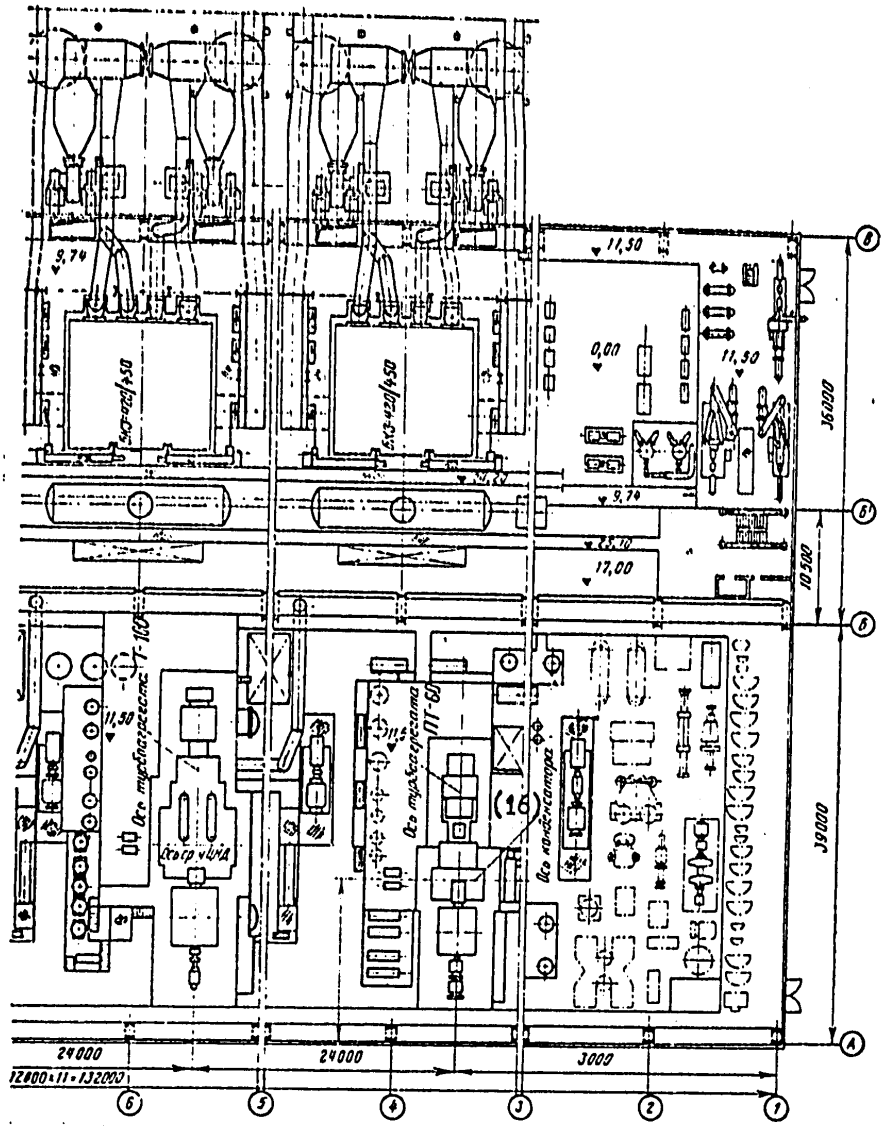


Fig. 3. Arrangement of equipment in main building of TETs-ZIGM. [right side]

b -- plan

Key to Fig. 3 on next page.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

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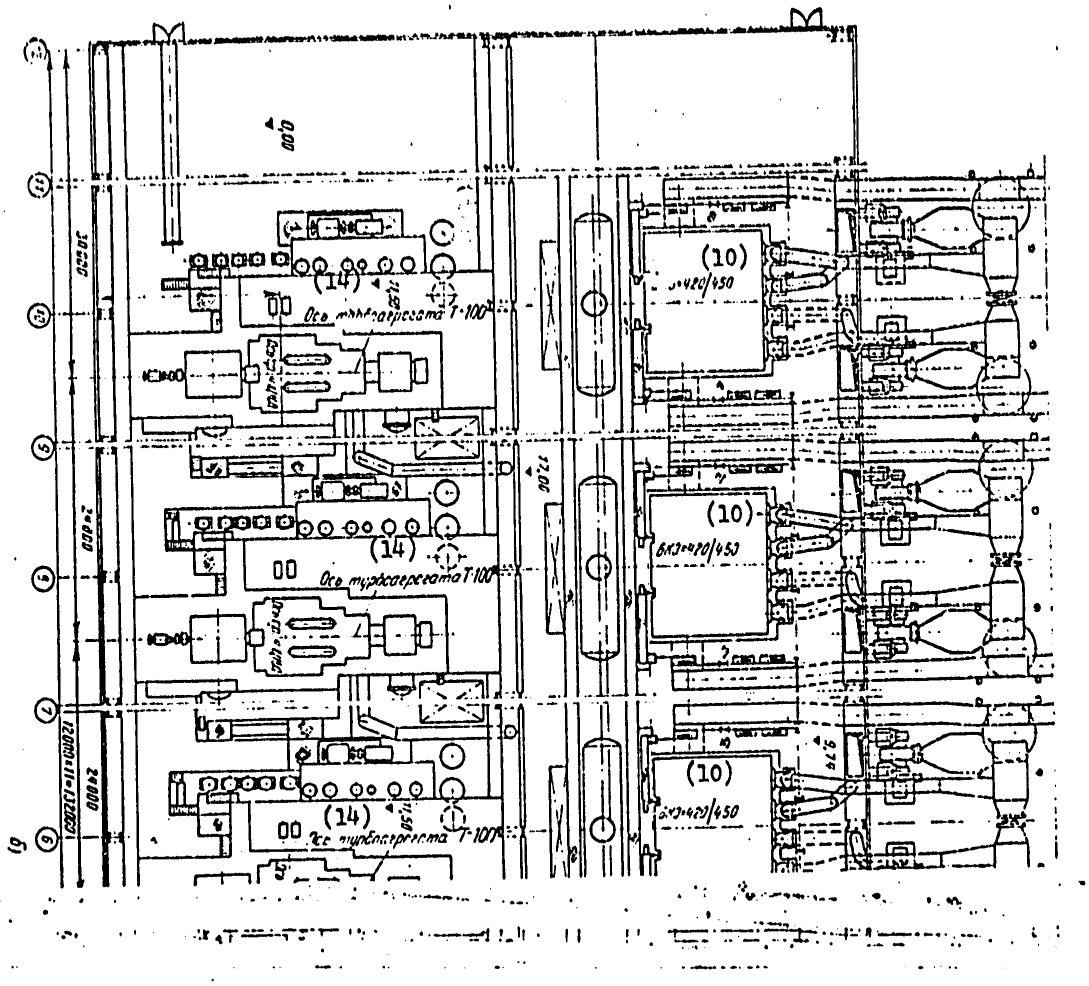


Fig. 3. Arrangement of equipment in main building of TETs-ZIGM. [left side]

b -- plan.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



Key to Fig. 3.

1. Deaerator 0.6MPa
2. Vacuum deaerator
3. Two cranes 30/5 tons each
4. Generator axis
5. Axis of middle part of TsND Low-pressure cylinder
6. Turbine assembly T-100-130 + TVF
7. Circulating water pipelines
8. Two cranes 30/5 tons each
9. TsTShch [Central heat control panel]
10. BKZ-420/450 boiler
11. Crane 15 tons
12. Gas pipeline
13. BKA = 420/450
14. Axis of turbine assembly T-100
15. Axis of turbine assembly PT-60
16. Axis of condenser

First version: power delivered to a high voltage 110kv network;

Second version: power delivered to buses of the main distribution system of the 6.0 (10.0)kv generator;

Third version (combination)-- power delivered to the 110kv network through step-up transformers and to the generator voltage network by reactive taps.

The design also recommends an efficient arrangement of the general plan (Fig. 2). Considerable reductions were obtained by grouping together the auxiliary structures making it possible to reduce the lengths between intershop pipelines. In the combined auxiliary building (OVK) were grouped the following: the shop for chemical preparation of water with external vats and a chemical reagent warehouse, central repair shops, a materials warehouse, an electrolyzer shop, fire-protection pumps, a flotation shop, a construction repair shop, charging facilities for power operated trucks, laundry, etc. The main building, the general service building and the OVK are interconnected by overhead bridges which is convenient for operating and repair personnel. It is recommended that the fuel oil storage facilities be located outside the basic area of the plant on a fenced-off site.

Arrangement and structural solutions of the main building. The transverse cross section of the main building is made in the form of a two-bay frame with a deaerator set of shelves built into the boiler room (Fig. 3).

The dimension of the building in the transverse direction, in meters, are as follows:

| | |
|---|---|
| Machinery hall | 39.0 |
| Boiler room with built-in deaerating shelving | 36.0 |
| Deaerator shelving | 10.9 |
| Pitch of the basic columns of the frame | 12.0 |
| Pitch of the shelving poles | 6.0 |



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



The main building has a steel frame. The columns of the built-in shelving has a solid cross section. The girders have parallel flanges. Beams carrying the cranes are solid. The skylight of the boiler department is slotted with drip pans (within the height of the girders for carrying away rain waters).

All sections of the main building are made of the same standardized plant manufactured members.

An open site adjoins the main building on the boiler department side where RVP and blowing fans are located. The site is serviced by a 20-ton gantry crane.

The machinery hall is equipped with two 50/10 ton-force overhead cranes and the boiler department -- with two 30/5 ton-force cranes.

Erecting the main building with two bays and built-in shelving made it possible to solve efficiently a number of problems related to conditions of industrial production of construction-installation work, as well as to provide improved conditions for repairs during operation.

When changing over to large unitized volumetric pipeline blocks of increased plant readiness which weigh up to 20 tons and are 12m long and insulated and metal plated, it was necessary to create a mechanized arrangement of tackle-installation that would satisfy modern requirements, provide safe working conditions and reduce labor and installation time.

The arrangement used in the TETs-ZIGM design of the main building with deaerator built-in shelving in the boiler department, serviced in the course of construction-installation work by overhead cranes of the boiler department, solved this problem.

The adopted arrangement of the cross section of the main building made it possible to install the structures of the deaeration shelving by means of the overhead cranes of the boiler department, because the rated arrangement of the main building provides for the transverse rigidity of the main building without the deaeration shelving.

A version of the installation by a specialized construction organization of structures of only two basic bays of the main building is possible so that the installation of the structures of the deaeration shelving and technological equipment can be done when installing technological equipment.

Since the structures of the built-in shelving are hinged to the basic frame and are not a part of the main building frame, the labor intensity of installing the structural metal of the deaeration shelving is reduced considerably due to the replacement of labor intensive rigid frame units by hinged ones.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



TETs designs used until now provide as a rule, a basement in the machine and deaeration departments, which usually requires a great amount of construction-installation work, especially if the ground water is present.

Since the construction work on underground structures of the main building must be done for the full rated capacity before the start of the installation work, the total time of building the TETs up to putting the first machine in operation is correspondingly lengthened.

To eliminate the indicated shortcomings, the following solutions were adopted in the TETs-ZIGM design: eliminate the basement and locate the auxiliary equipment on levels 0.00 and +4.00; replace solid roof on level 4.00 (previously 0.00) by an insular roof; replace the reinforced concrete posts supporting the roof at level ±4.00 with foundations of the sleeve type, by fully-prefabricated foundations of the type used in network construction. Such fully-prefabricated posts and light technological equipment are installed directly on a reinforced "power floor" or level 0.00 without building special foundations.

Numerous reinforced concrete foundations under auxiliary equipment, usually built on various levels below ground level, were replaced by a single reinforced concrete plate laid only slightly below ground level (0.3 - 0.5m) on which, besides roof posts at level 4.00, is installed all auxiliary equipment. The depth of anchor bolts of the auxiliary equipment can be reduced to 0.5 - 0.4 by using epoxy tars.

The design and arrangement solutions adopted for the zero cycle made it possible to reduce sharply the volumes of construction-installation work and create considerably more comfortable operating conditions compared to conditions in an underground basement (possibility of flooding by ground and surface waters and lack of daytime lighting).

Increasing plant readiness in construction structures and technological equipment. To obtain a considerable reduction in labor on the construction site maximum possible plant readiness of construction structures and technological equipment supplied to the construction site in an absolute primary condition which, in principle, radically changes the nature and volume of construction-installation work.

It is well known that labor productivity under comfortable plant conditions taking into account the possibility of mechanization and automation of technological processes even for small series production is at least two to three times higher than the labor productivity of a worker doing the same work on the construction site where it is organically impossible to create the same conditions as at the plant.

To organize plant production of units and structures, the availability of corresponding documentation is a necessary condition.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



In this connection, in the design of series produced TETs, special attention is given to the preparation of working drawings. Structures are supplied in units with a maximum amount of parts in the units. Supplying "loose" parts is allowed only when a technical study indicates that it is impossible or clearly unfeasible to include a part in the unit. The size and weight of the units make it possible to transport them on RRs. The units are designed to be used under operating and installation-transport conditions. Drawings of large unitized blocks indicate places and arrangements for slinging. The design of the blocks and units specifies the observance of plant and installation technological effectiveness. The formulation of the working drawing meets modern requirements of documentation for plant manufacturing.

After the decision was adopted on using the gas-tight BKZ-420-140 NGM Barnaul Plant boiler for all construction technological sections of series built TETs-ZIGM, the plant changed the design of the boiler to improve the technological effectiveness of its installation.

The prevailing parts of the boiler do not require preinstallation consolidating assembly and organization of corresponding areas on the construction site.

There are drawings for each section of the main building. The structural metal sections of the main building for all series TETs-ZIGM will be made in accordance with this single typical documentation which must be used by all manufacturing plants. These drawings are developed by taking into account unit delivery and installation with a minimum of installation units. Fastenings for pipelines, wall panels and casements are included in the basic structures.

Roofs are made of fully prefabricated complex panels using shaped steel sheets.

Drawings of special wall panels were developed for passing a large number of technological pipelines and KVO [Auxiliary boiler equipment] ducts through exterior walls which reduces manual labor considerably

The result was to make it possible to eliminate fully concreting in place of a large number of small sections of the roof and avoid laying small amounts of bricks in the wall, i.e., reduce the construction part only to installation and free part of the construction personnel from low productivity labor.

Flow line series construction of thermal electric power plants, including GRES, also requires the creation of regional consolidating-procurement bases. One of such bases is being built at present in the construction region of the Minsk TETs-4 using the TETs-ZIGM design.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



As a result of the above indicated technical solutions and measures, the following unit technical-economic indicators were obtained:

| | |
|---|---|
| Cost of 1km of installed capacity | 154 rubles/kw |
| Cost of construction-installation work | 84 rubles/kw |
| Unit labor per unit installed capacity | 1.9 man-days/kw |
| For main building: | |
| construction volume | 0.815 $m^3$/kw |
| area of construction | 0.023 $m^2$/kw |
| consumption of structural steel | 8.1 kg/kw |
| consumption of concrete and reinforced concrete | 0.020 $m^3$/kw |

To determine the unit technical-economic indicators of the main building and approximate indicators for the TETs, a main building with the following composition of sections was assumed as an example: one constant end section, one PT-60 section, three T-110 sections and one temporary end section.

The unit construction cost of a TETs may vary from 145 to 170 rubles/kw depending upon the combination of equipment and local conditions.

At present, the TETs-ZIGM design is used for designing and building 17 TETs with a total rated capacity of about 6.0 x $10^6$ kw. The first units were put in operation in 1975 at the Kuybyshevskaya and Kaunasskaya TETs

On the development of a design of series built TETs using solid fuel. According to the plan for building TETs in the Tenth Five-Year Plan period, a large number of TETs is located in regions using solid types of fuel.

In the next ten years, it is planned to install at TETs tens of coal-dust boilers with a total steam productivity of about 55,000 tons/hour. Of these, about 70 percent will burn Ekibastuz and Kanso-Achinsk coals. A pressure of 13MPa (130 kg-force/$m^2$) will be very promising in coal-dust TETs.

The indicated scale of putting boilers in operation which are solid fuel makes it feasible to develop standardized designs for the main building of TETs using coal dust.

At present, several typical and individual designs with 320 and 420 tons/hour boilers are available. However, an analysis of these designs shows a large variety of design solutions. This is expressed by variations in the dimensions of a boiler cell from 24 to 36m, bays in the boiler in the bunker storage department and the deaerator shelving area from 9 to 12m of various heights and servicing elevations.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



These differences can be found in designs of TETs using the same type of solid fuel.

It is now urgent to find and develop a design of a series TETs burning solid fuel that would provide a single type of construction and technological solutions. This problem is considerably more complex than designing a series of gas-fuel oil TETs due to the differences in the physio-chemical properties of coal and the resulting necessity of using several types of boilers differing by the structure of the heating-connection surfaces, arrangements for a coal-dust preparation and for removing slag and ashes.

The work done by the VNIPIenergoprom Institute showed that in spite of the great number of factors affecting grouping and technological solutions, it is possible, for standardization purposes, to limit oneself to three TETs modifications:

a) for fuels of the type of Kuznets oxidized, Irsha-Borodinskiy and Nazarovskiy coals, with a closed system of coal-dust preparation, with an intermediate bunker and liquid slag removal;

b) for lignite coals of the type of Ageyskiy and Raychikhinskiy coals, with a closed system of coal-dust preparation with solid slag removal;

c) for coal of the Kuznets type, with a closed system of coal-dust preparation with an intermediate bunker and hard slag removal.

All of the indicated technological solutions may be used on the basis of a standardized BKZ-420 tons/hour boiler. This makes it possible to use a single-size boiler cell for all the above-indicated types of solid fuel.

An exception are boiler cells for burning Ekibastuz coals for which the feasibility of using a T-shape arrangement of the boiler assembly is acknowledged.

The work done indicated that boiler assemblies for all technological arrangements can be placed in a 24.0m cell, but rather complex conditions are created in this case for mechanized repairs of the heating surfaces of the boilers.

To create the most favorably conditions for servicing and repairing, it is planned to adopt a dimension of 30.0m for the standardized boiler cell and 24.0m for a boiler cell burning Ekibastuz coals.

The experience of designing series TETs-ZIGM burning gas-fuel oil indicated that an indispensable condition for designing a TETs for multiple use is the creation of comprehensive construction-technological sections. As a result of working on many versions of series TETs



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8



which burn solid fuels, it is planned to use the following construction-technological sections from which the main building can be composed of any given equipment:

| | |
|---|---|
| "Constant end" section | 12.0 x 2 = 24.0m |
| Temporary end section | 12.0 x 1 = 12.0m |
| Peak boiler section | 12.0 x 2 - 24.0m |

It is proposed tomake the boiler-turbine PT-60 (PT-80), T-110 and R-50 sections in two versions for two and three bays per section. PT-135, T-175 and R-100 turbines will have five bays each. This solution was required because machinery hall cells for this type of turbine require 24.0m and boiler cells -- 30.0m. By placing side-by-side construction-technological sections of two dimensions: 24.0m and 36.0m, we preserve the required boiler pitch of 30.0m. The areas free from technological equipment in the machinery hall in 30.0m sections for turbines PT-60, T-110 and R-50 and in 60.0m sections for turbines PT-135, T-175 and R-100 are used as repair areas, which makes it possible to eliminate final gathering sections designated for this purpose.

In connection with the fact that at coal-dust TETs when fuel oil is not available and where power boilers are used to span thermal peak loads, obviously, a section will have to be created of a peak steam boiler with the installation in the machinery hall of this section of corresponding thermification equipment (peak network heaters, etc.). Work is being done on creating water heating boilers using solid fuel, which will provide the peak heat load.

In the "constant end" section are located the general-plant equipment and services that have to be in the main building (shops, etc.), as well as areas for placing equipment during repairs.

The temporary end section is used for industrial large-unit installation of the thermo-mechanical equipment of the end technological section, laying-out the equipment during repairs and repairs of transformers.

The key question of developing a standardized design of TETs using coal-dust is the selection of a single cross section of the main building.

The following rules were adopted in developing arrangements: The BKZ 420 tons/hour boiler unit was adopted as a basis, since it made it possible to ease the conditions for standardizing the arrangement of the main buildings; the bay and arrangement of the machinery hall was adopted, the same as in the series TETs-ZIGM design -- 39.0m; no basement for the main building and levels for servicing the machinery hall -- 0.00, 4.00 and 12.00m; the same arrangement of the cross section of the main building was adopted, although the arrangements for coal-dust preparation and slag-ash removal are different.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100060060-8

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The load-bearing structures may be made of metal or reinforced concrete.

One version of an arrangement which merits attention is the one with one 12.0m bunker shelving bay, locating the deaerator in the bay of the machinery hall on the 12.0m servicing level, using feed water of the feed pumps with reduced height of suction. The implementation of solutions for this version is being done jointly with the feed pump manufacturing plant.

In conclusion, it should be noted that the developed design of the TETs-ZIGM and work on series TETs using coal-dust are only the first stages that involve using equipment that have high technical-economic indicators and remain promising for use in the very near future, are supplied by industry and are used in series TETs at present. Further work on creating new designs must be based on new progressive equipment that would play a basic role in raising the technical-economic indicators of TETs; including reliability of operation. We speak, first of all, about the boiler units -- compact with a vortex furnaces, with fluidized beds, as well as gas-tight and of suspended design. It is necessary also to accelerate the work on creating a boiler unit with steam productivity of 800 tons/hour.

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FUELS AND RELATED EQUIPMENT

UDC 622.2.06.002.237(084.2):622.272.633(477.61/.62)

INSTITUTE OFFERS NEW PRINCIPLES AND PLANS FOR MINE OPERATION

Kiev UGOL' UKRAINY in Russian No 4 Apr 1979 pp 1-5

[Article by Candidate of technical sciences A. F. Ostapenko, Ukrainian SSR Ministry of the Coal Industry, Doctor of technical sciences B. K. Kuklin, Candidate of technical sciences A. G. Lepikhov, DonUGI [Donets Scientific-Research Coal Institute] and Engineer V. I. Shevtsov, Ukrainian Republic Trade Union Committee of Coal Industry Workers: "Paths Towards Reconstruction of Mining the Donbass Mines"]

> [Text] "Planning the development of the national economy is one of the most important scientific and social achievements of the 20th century and the revolutionary practice of transforming public life."
>
> From a speech of the CPSU Central Committee "On the 50th Anniversary of the First Five-Year Plan for the Development of the USSR National Economy."

In the last 15 years at the mines of the Donets basin the technical rearming of the working faces has been carried out at high rates using the mechanized complexes KM-87, KMK-97, "Donbass," narrow-range combines 2K-52, 1K-101, MK-67, and the grading units USB-67 and UST-2a. The level of narrow-range excavation on the gently sloping beds has reached 90% including 57.4% by the complexes. The introduction of such technology has been accompanied by a considerable increase in the load on the main production links. Thus, the load on the shaft, gallery, slope and and working face has risen on the average 1.6-fold, the quantity of active galleries has been reduced by 34%, and the working faces by 28%.

The increase in the loads on the production links and the need to concentrate mining have required a radical improvement in the planning and perfection in the management of the mines: transition to more efficient columnar systems of working, and to gallery-by-gallery and panel methods of preparing the shaft fields; increase in the cross section area of the preparatory work in order to improve the throughput (for transportation and ventilation). However, under constantly exacerbating conditions (67% of the shaft beds are worked under complex geological conditions, about 30% of the coal is mined from blow-out-dangerous beds, and over 35% of the longwalls are worked off on beds with gassing over 10 $m^3/T$) the measures taken for the



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reconstruction of mining in individual cases do not yield positive results. Drifts (especially inclined), despite the increase in the depth of the working, as before, are usually driven in undischarged zones, often in zones of the adverse effect of mineral extraction or bearing pressure from coal pillars left in neighboring beds. Discharge of mining pressure in the columnar system by active longwalls by means of frontal overworking in a formed zone of temporary bearing pressure results in deformation of the drifts. Therefore special discharging low-output longwalls are recommended that require additional stratal drifts and a large volume of auxiliary work.

Due to the short length of the panel wing that on 70% of the excavation sections with comprehensively mechanized longwalls is 500-100 m the volume of work for assembly-disassembly of the complexes and other equipment rises. A change in the length of the longwall also has a great influence on the conditions for working the working face. As the longwall becomes longer the per unit participation of time for fulfilling the auxiliary work on the terminal sections is reduced, but the heat- and gas-saturation of the air stream is increased, the time for advance of the workers along the face rises, and the danger of spontaneous combustion of the coal also increases.

The drifts can be discharged of mining pressure, the cost of their ventilation and maintenance can be reduced, and the optimal length of the longwall can be changed by discharging the beds with their subsequent degasification. Under the extant order for carrying out mining work and modern technology a large volume of local measures is carried out at the shafts, including drilling wells for moistening and degasification of the coal in the bed, injection of water in a pattern of soil loosening, and other purposes. These processes are labor intensive, significantly reduce the intensity and increase the number of operations for carrying out the work, impair its specialization and concentration, and do not always guarantee safety. The use of diverse and multiple-operation local measures (about 570 longwall assemblies) impairs control over their quality fulfillment.

The effectiveness of degasification of undischarged beds is 20-25%, and of accessories 40-60%; it is used on gently sloping beds respectively on 18 and 190 excavation sections. The pre-overworking or chipping away attains a high (up to 90%) efficiency of degasification, and discharges of coal and gas are completely prevented. The transition to schemes of ventilation with thinning of methane with respect to the sources of its entrance on the undischarged beds results in difficulty in maintaining the drift behind the longwall, impaired maintenance of joining the longwall to the drift, and so forth.

In the mines of the republic in the space of a year about 3,000 km of drifts have been refastened. About 30,000 workers have been involved in their repair, and the labor intensity has been 46-man shifts per 1000 T of coal. The outlays to maintain the driftscan be lowered if coal pillars are not left in the neighboring beds. But under the extant planning schemes it is impossible to guarantee high technically and economically expedient concentration of mining (more than one longwall in a wing) with pillarless



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coal excavation which is employed only on 70% of the excavation sections, and generally with simultaneous working off of not more than two longwalls in the panel. The graduated scheme of preparation with main drifts in the working off of beds by upwalls due to the lack of the necessary technology with angle of incidence over 10° is not used. Meanwhile with the indicated preparation pillarless excavation is possible with a high level of concentration of mining since there are always the main drifts from which one can open several fronts and carry out excavations cross to the worked space.

In many shafts the preparation of working faces is territorially combined with work to mine coal, and consequently, both are carried out from the same drifts as the work to prevent the adverse effect of natural forces. In addition, many auxiliary works are not separated territorially from the extracting work which reduces the reliability of the technological plan of the shaft (continuity of the work), impairs the maintenance of sections that can be reused for ventilation, excavation drifts, and places limitations on the rates of driving the sectional drifts. Discharging of the beds and territorial separation of work for preparation of the line of working faces from the work for coal mining guarantee the best potentialities for degasification and isolated ventilation of the preparatory drifts, reduce the need for increasing the amount of air fed to the section, and improve the conditions for maintaining the drifts.

In order to eliminate the listed shortcomings the following, in our opinion, more expedient trend in conducting mining work is necessary which provides:

a) expansion of the volume of use of regional protection and discharge of blow-out-dangerous and very gaseous beds;

b) reduction on the unprotected beds of the per-unit participation of main drifts that require local discharge by inefficient and complicated methods; increase in the per-unit participation of effective and low labor-intensive combinations of methods of local discharge of the main drifts; possibility of stopping on the repair of the main inclined drifts when it is impossible to avoid their overworking by the longwalls under the formed temporary bearing pressure;

c) complete territorial separation of work for the preparation of a line of working faces and their operation;

d) high concentration of mining in pillarless excavation by means of perfecting the panel and creating combined schemes for preparing the shaft fields possessing new, progressive properties;

e) reduction in the contacts of the workers with adverse phenomena of nature by means of comprehensive realization of points a, b, c and d.



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In order to implement such a trend in carrying out mining work it is necessary to solve a number of problems:

I. Selection of the optimal order for working off the beds that guarantees the protection and discharging of the greatest number of them, which will permit implementation of the mining in the discharged zone, and on the blow-out-dangerous beds--in the protected zone. The method of preliminary preparation of the series and discharge of the beds is being successfully employed abroad [1].

Studies [2] have established that under certain conditions in preliminary chipping away of the bed the strength of the coal is increased from 5-7 to 20-40 kg-f/cm$^2$, inrushes of the false roof are prevented, and one can switch from hammer to combine excavation (as a result of discharging of another bed the strength rose from 15-40 to 140 kg-f/cm$^2$).

In the mines of the Ukrainian SSR Ministry of the Coal Industry over 400 longwalls operate with lowering of a false roof. If the beds are preliminarily discharged then there is reason to expect that with a rise in the stability of the rocks in individual cases the volume and area of the lowered false roof will be reduced and the quality of the coal will be improved. Expansion of the order of working the beds in which the greatest number of shaft beds are protected and discharged to a considerable measure is possible due to the increase in per-unit participation of the ascending order of working off of the beds over 0.7 m thick to 50%.

II. Territorial separation of work to prevent adverse manifestations of natural forces and preparation of the working front from work on coal mining. It is expedient in the absence and in the presence of discharging the rock series: it improves the intensity, safety of mining, and level of concentration of mining work; it also has other important advantages such as the possibility of improving the use of technology and reducing the volume of auxiliary manual work; acceleration of the preparation of working face lines; reduction in the multiple operations and improvement in the reliability of the production schemes; organization of pillarless excavation of coal, and improvement in maintaining the drifts; improvement in the working conditions.

Complete territorial separation of work to prepare and operate the working front is efficient first of all on the new shafts and galleries. In the operating shafts with fairly large (suitable for excavation) supplies where new galleries will no longer be built, for this purpose modernization can be implemented (specialization of the transportation shafts, territorial separation of the streams of coal from the streams of other loads, reduction in the length of conveyer lines, the number of conveyers in them, and perfection of the operating pattern of the longwalls). In individual shafts there are examples of the territorial separation of work in the limits and beyond the limits of the excavation sections by means of using a block plan for cutting the shaft field, the columnar system of working, and other measures.



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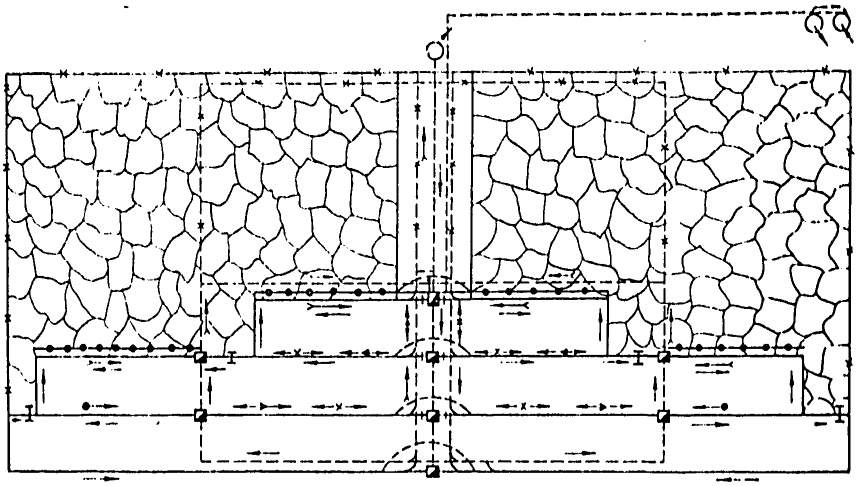
III. Creation of long-term plans for the preparation of shaft fields. The tasks that depend on the mutual arrangement of drifts and their parameters cannot be solved without perfection of the plans for the preparation of the shaft fields. Studies of Donugi [Donets Scientific Research Institute of Coal] have established that at the given stage of development of mining the nature, properties and possibility of perfecting the plans for preparing the shaft fields depend on the completeness and degree of use of the following principles: dispersal and grouping of the inclined drifts; specialization of the inclined drifts; rapid servicing of the working and preparatory faces by the preparatory drifts. The preparation plans are designed by using one or several principles, as a result of which plans are created for the preparation of the shaft fields that guarantee the solution to such problems:

1) complete territorial separation of work to prepare and operate the line of working faces, including separation of work for carrying out (and partially for maintaining the drifts, assembly, dissassembly and delivery of the main mass of equipment) from the main work for coal mining;



Conventional designations

- Delivery of people
- Delivery of materials and equipment
- Delivery of rock
- Delivery of coal
- Fresh stream
- Outgoing stream
- Shaft
- Well
- Blind Shaft
- Hoist chamber

Figure 1. Panel Plan of Preparation with Driving Excavation Drifts from Central Inclined Drifts



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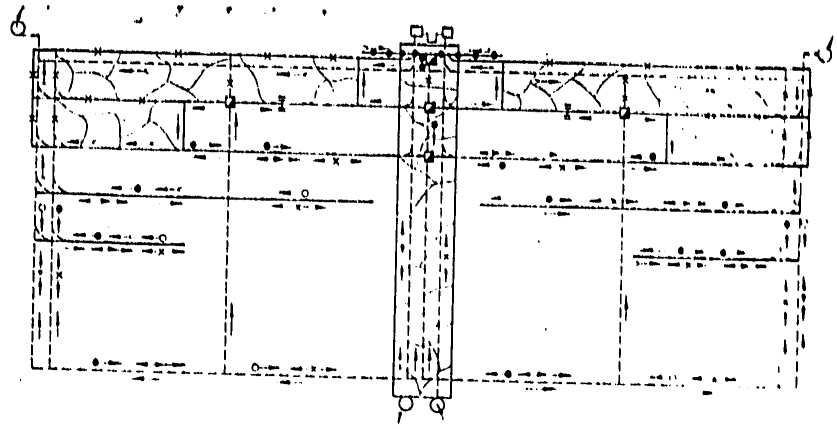

Figure 2. Combined Plan of Preparation with Driving Excavation Drifts from Specialized Wing Inclined Drifts

2) increase on this basis the rates for driving drifts, the rate of preparing faces, the throughput of transportation, reduction in the number of operations fulfilled on the course of the production chains, their simplification, and increase in the intensity of mineral extraction;

3) growth in the level of concentration of mining in space during pillarless excavation;

4) increase in the percentage of use of effective local methods of discharging and protecting the inclined drifts, reduction in the per-unit participation of low-efficiency methods;

5) improvement in control over the parameters of excavation sections (drifts) and primarily an increase in the optimal size of the length of the wing, panel and the time for working them, and this means a reduction in the volume of work for the delivery and reassembly of mobile and stationary equipment;

6) improvement in the effectiveness of degasification of the beds and accessories, separation of work to carry out local measures in the drilling faces from work in the working faces; growth in the intensity of excavation of protective beds by means of increasing the number of simultaneously workable longwalls in the wing.

Below plans are given for preparing the shaft fields that were compiled by Donugi with regard for the listed principles.



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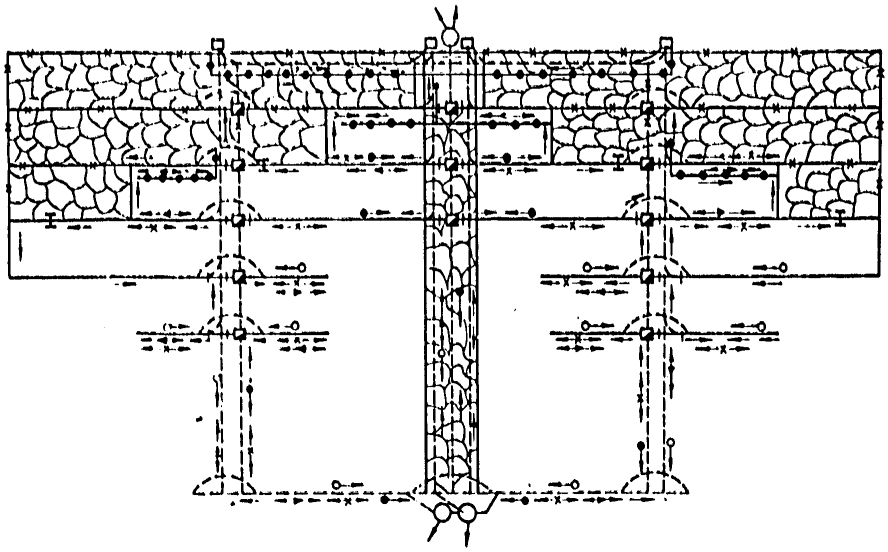

Figure 3. Combined Plan of Preparation with Driving of Excavation Drifts from Specialized Duplex Inclined Drifts Made in the Middle of the Panel Wing

Plan 1--panel (figure 1); based on the partial specialization of the inclined drifts and rapid principle of servicing the faces with dispersal of the inclined drifts. The coal from the longwalls is delivered to the central inclined drifts, intermediate drifts are made in the middle of the panel wing, and they are used to maintain the excavation drift behind the upper longwall and to ventilate the lower. With respect to technical conditions the plan can be used in the active deep and gas shafts during working off of the panels of varying width, including panels with unequal wings that can be prepared on beds with impassable wing geological ruptures. In the short wings (less than 1 km) one can work off one longwall and not drive an intermediate inclined drift. The plan is more effective where the level of concentration of mining in space has the greatest value, i.e., on thin beds with low load on the longwall. In light of the increase in length of the panel wing all the work associated with discharging the central inclined drifts has to be done on sections with greater supplies of coal, for which reason their per-unit participation is reduced. Shortcomings of the plan--incomplete solution to problems 1 and 2 due to the partial separation of preparation of the working face line from work for operation, and then only in time.

Plan 2--combined (fig 2); based on the complete specialization of the dispersed inclined drifts. The excavation drifts are driven from the wing inclined drifts, while the coal is transported from the longwalls to the



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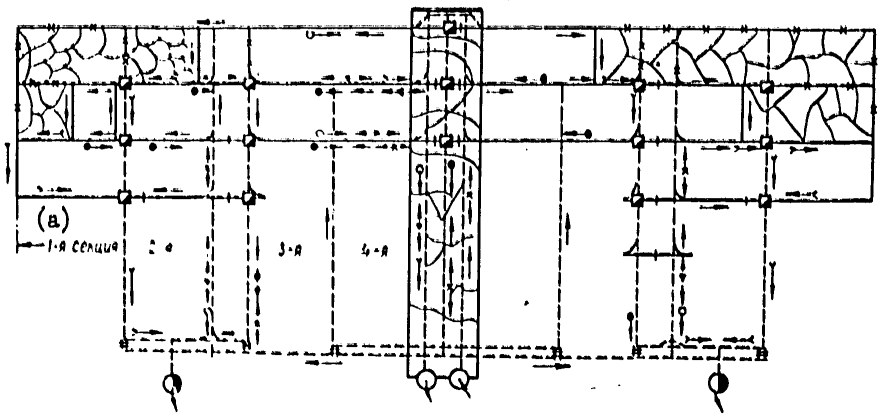


Figure 4. Combined Plan of Preparation with Alternate Driving of Excavation Drifts from Duplex Drifts Located on Wings and In Center of Shaft Field

Key:

a. first, second, third, fourth section

central; intermediate in the middle of the wing are extinguished as the supplies are worked off. The plan can be employed on new gas and deep shafts when there are (made during construction) wing shafts that can be used during operation to drive excavation drifts. For this purpose during operation instead of a bucket lift a double-ladle (holding capacity of the ladle 6 $m^3$) or single-ladle (9 $m^3$) lift is used. All the listed problems are solved with this plan.

Plan 3--combined (fig 3); the coal is transported to the central inclined drifts. In the middle of the wing connected intermediate inclinded drifts are driven that are designed only for making excavation drifts. Due to this dispersal and specialization of the inclined drifts are guaranteed. As the levels are worked off one of the inclined connected drifts is eliminated, while the other after its overworking if necessary is stopped for repair until passage of the excavation drifts. This is possible because the length of the excavation drifts is two times shorter than the length of the panel wing, and consequently there is a sufficient supply of time for the preparation of the layer. For this same reason the plan guarantees rapid preparation of the excavation sections. It can be used in very gaseous and deep new or reconstructed shafts.

Plan 4--combined (fig 4). The shaft field is divided into three sections: central two-sided and two wing one-sided. The first excavation sections are prepared on the wing sections with their subsequent working off with



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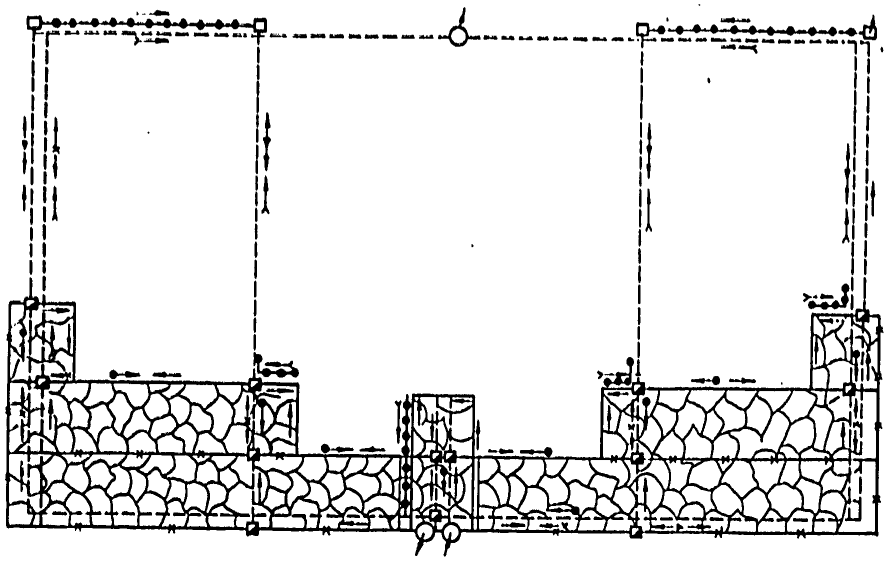

Figure 5. Combined Plan of Preparation with Driving of Excavation Drifts behind Longwall

transporting of the coal from the longwalls to the inclined drifts driven on the boundaries of the central section; the drifts here are overworked. Then the working faces begin to be serviced by those excavation drifts that previously were driven in the central section. Consequently, the plan guarantees rapid servicing of the longwalls by the inclined drifts and excavation drifts (at first wing, then central); the change of functions of the inclined drifts is also guaranteed (for servicing first the working faces, then the preparatory). These drifts made on the boundaries of the central section are eliminated by the sections after their overworking, at the end of which driving of the excavation drifts begins. In order to ventilate the longwalls and drifts additional single inclined drifts are made that are eliminated as the levels are worked off, as a result of which the plan can be employed also on deep shafts.

The plan makes it possible to completely solve five of the first main problems and partially the sixth. Plan 4 is designed only for new shafts with great (8 km and over) length of the shaft field with respect to extent on the non-blow-out-dangerous beds, as well as on the blow-out-dangerous, preliminarily discharged or with angle of incidence less than 10°. In the given case the movement of the stream of air coming from the working faces is descending; with ascending movement the plan can also be used on blow-out-dangerous beds.



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Plan 5--combined (fig 5). In the center of the shaft field and in the middle of each wing field inclined drifts are driven (on the boundaries of the shaft wing connected drifts are driven). The levels are worked off in an ascending order. With respect to extent there are four longwalls operating and one upwall in the center of the field under whose drift space field inclined drifts are driven. The excavation drifts are driven behind the longwalls and are reused as transport drifts. The plan makes it possible to specialize the inclined drifts, and guarantees the rapid servicing of the working faces by the inclined drifts and a high level of concentration of the work. The rocks from the driving of the drift remain in the shaft, and therefore the use of the plan is expedient wherever the lift and the rock managment is the bottleneck.

All the plans permit freshening of the outgoing stream of air before it is removed with the help of sectional pipes by means of general-shaft depression or dilution of methane in the drifts with respect to the sources of its entrance. Thus, as compared to the plans used the plans given guarantee a higher level of concentration of mining, simplify the technology of preparing and working off of the beds, and reduce the contact of the workers with adverse and dangerous phenomena of nature.

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FUELS AND RELATED EQUIPMENT

TABLES OF 1978 UKRAINIAN COAL PRODUCTION

Kiev UGOL' UKRAINY in Russian No 4, Apr 79 pp 46-47

[Tables Listing Coal Statistics]

Table 1

| (1) Производственные объединения | (2) Добыча угля, тыс. т | (3) Кол-во действующих очистных забоев | (4) Среднедействующая линия очистных забоев, км | (5) Среднесуточное подвигание действующих очистных забоев, м | (6) Суточная нагрузка, т: (7) на действующий забой | (8) на шахту (адм. единицу) |
|---|---|---|---|---|---|---|
| Донецкуголь (9) | 21918 | 179 | 32,03 | 31,5 | 362 | 2919 |
| Макеевуголь (10) | 15718 | 140 | 21,79 | 32,4 | 327 | 3112 |
| Красноармейскуголь (11) | 13696 | 75 | 12,96 | 45,2 | 519 | 3667 |
| Добропольеуголь (12) | 11035 | 42 | 7,42 | 62,1 | 834 | 3646 |
| Артемуголь (13) | 11759 | 209 | 21,94 | 38,5 | 156 | 2315 |
| Орджоникидзеуголь (14) | 6295 | 100 | 10,63 | 31,4 | 178 | 1834 |
| Шахтерскантрацит (15) | 12668 | 103 | 17,01 | 35,0 | 369 | 1958 |
| Торезантрацит (16) | 11181 | 90 | 13,78 | 33,1 | 367 | 1933 |
| Ворошиловградуголь (17) | 11486 | 75 | 12,00 | 40,3 | 460 | 3070 |
| Стахановуголь (18) | 9903 | 117 | 19,11 | 28,4 | 244 | 1632 |
| Первомайскуголь (19) | 9797 | 78 | 15,63 | 28,4 | 338 | 1807 |
| Краснодонуголь (20) | 9080 | 59 | 7,62 | 48,7 | 491 | 2739 |
| Донбассантрацит (21) | 22288 | 154 | 26,37 | 34,1 | 433 | 2747 |
| Свердловантрацит (22) | 9265 | 41 | 5,86 | 59,8 | 693 | 2115 |
| Павлоградуголь (23) | 8812 | 53 | 7,87 | 57,5 | 520 | 3249 |
| Укрзападуголь (24) | 15064 | 94 | 11,62 | 52,9 | 538 | 2243 |
| Александрияуголь (25) | 10979 | 13 | 0,98 | 63,9 | 862 | 4007 |
| Минуглепром УССР (26) | 210944 | 1622 | 244,83 | 37,1 | 370 | 2556 |

Key:

1. Production asscciations
2. Coal output, thousands of T
3. Number of active working faces
4. Average active line of working faces, km
5. Average monthly advance of active working faces, m
6. Daily load, T
7. for active face
8. for shaft-pit (adm. unit)
9. Donetskugol'
10. Makeyevugol'
11. Krasnoarmeyskugol'
12. Dobropol'yeugol'
13. Artemugol'
14. Ordzhonikidzeugol'
15. Shakhterskantratsit
16. Torezantratsit
17. Voroshilovgradugol'
18. Stakhanovugol'

[Key continued on next page]



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19. Pervomayskugol'
20. Krasnodonugol'
21. Donbassatratsit
22. Sverdlovantratsit
23. Pavlogradugol'
24. Ukrzapadugol'
25. Aleksandriyaugol'
26. Ukrainian SSR Ministry of the Coal Industry

Table 2

| (1) Производственные объединения | (2) Комплексно механизированные забои, оборудованные комбайнами и стругами на пластах с углом падения до 35° | | | |
|---|---|---|---|---|
| | (3) Количество | (4) Добыча, тыс. т | (5) % к добыче из действующих очистных забоев на пластах с α < 35° | (6) Нагрузка на забой, т |
| Донецкуголь (7) | 47 | 10298 | 48,7 | 658 |
| Макеевуголь (8) | 36 | 7444 | 51,6 | 647 |
| Красноармейскуголь (9) | 45 | 8277 | 65,2 | 596 |
| Добропольеуголь (10) | 31 | 8216 | 80,5 | 961 |
| Шахтерскантрацит (11) | 18 | 3200 | 26,2 | 524 |
| Торезантрацит (12) | 37 | 5712 | 56,7 | 556 |
| Ворошиловградуголь (13) | 22 | 5268 | 53,8 | 715 |
| Стахановуголь (14) | 13 | 1790 | 22,5 | 459 |
| Первомайскуголь (15) | 14 | 2187 | 25,8 | 599 |
| Краснодонуголь (16) | 30 | 6331 | 86,2 | 724 |
| Донбассантрацит (17) | 43 | 9681 | 48,0 | 687 |
| Свердловантрацит (18) | 34 | 8007 | 92,4 | 794 |
| Павлоградуголь (19) | 45 | 7675 | 91,1 | 571 |
| Укрзападуголь (20) | 55 | 10960 | 74,9 | 700 |
| Александриауголь (21) | 13 | 2889 | 100,0 | 862 |
| Минуглепром УССР (22) | 483 | 97935 | 57,8 | 670 |

Key:

1. Production associations
2. Comprehensively mechanized faces equipped with combines and graders on beds with angle of incidence to 35°
3. Number
4. Output, thousands of T
5. % of output from active working faces on beds with α<35°
6. Load on longwall, T
7. Donetskugol'
8. Makeyevugol'
9. Krasnoarmeyskugol'
10. Dobropol'yeugol'
11. Shakhterskantratsit
12. Torezantratsit
13. Voroshilovgradugol'
14. Stakhanovugol'
15. Pervomayskugol'
16. Krasnodonugol'
17. Donbassantratsit
18. Sverdlovantratsit
19. Pavlogradugol'
20. Ukrzapadugol'
21. Aleksandriyaugol'
22. Ukrainian SSR Ministry of the Coal Industry



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Table 3

| (1) Производственные объединения | (2) Проведение подготовительных выработок | | | | | |
|---|---|---|---|---|---|---|
| | (3) всех | | | (4) вскрывающих и подготавливающих | | |
| | План., км (5) | Факт., км (6) | % к плану (7) | План., км (5) | Факт., км (6) | % к плану (7) |
| Донецкуголь (8) | 290,0 | 293,2 | 101,1 | 210,0 | 212,3 | 101,1 |
| Макеевуголь (9) | 213,5 | 217,0 | 101,6 | 148,5 | 149,3 | 100,5 |
| Красноармейскуголь (10) | 172,4 | 153,2 | 88,9 | 154,3 | 132,1 | 85,6 |
| Добропольеуголь (11) | 179,0 | 170,6 | 95,3 | 119,7 | 105,9 | 88,5 |
| Артемуголь (12) | 339,0 | 339,0 | 100,0 | 165,5 | 165,7 | 100,1 |
| Орджоникидзеуголь (13) | 139,0 | 136,9 | 98,4 | 72,7 | 71,5 | 98,3 |
| Шахтерскантрацит (14) | 144,0 | 146,6 | 101,8 | 98,0 | 98,8 | 100,8 |
| Торезантрацит (15) | 127,4 | 133,2 | 104,5 | 85,4 | 85,6 | 100,2 |
| Ворошиловградуголь (16) | 174,6 | 170,7 | 97,7 | 98,0 | 98,5 | 100,5 |
| Стахановуголь (17) | 214,2 | 215,2 | 100,5 | 122,0 | 123,8 | 101,5 |
| Первомайскуголь (18) | 159,0 | 150,1 | 94,4 | 112,0 | 107,9 | 96,3 |
| Краснодонуголь (19) | 132,0 | 129,2 | 97,8 | 70,8 | 70,8 | 100,0 |
| Донбассантрацит (20) | 275,5 | 266,2 | 96,6 | 144,4 | 138,7 | 96,1 |
| Свердловантрацит (21) | 103,9 | 107,8 | 103,7 | 72,0 | 71,3 | 99,02 |
| Павлоградуголь (22) | 112,8 | 112,8 | 100,0 | 105,9 | 106,0 | 100,09 |
| Укрзападуголь (23) | 134,2 | 139,6 | 104,0 | 115,6 | 119,4 | 103,3 |
| Александрияуголь (24) | 29,9 | 31,5 | 105,4 | 27,4 | 29,1 | 106,2 |
| Минуглепром УССР (25) | 2940,4 | 2912,8 | 99,06 | 1931,2 | 1896,7 | 98,2 |

Key:

1. Production associations
2. Driving of preparatory drifts
3. all
4. stripping and preparatory
5. planned, km
6. actual, km
7. % of planned
8. Donetskugol'
9. Makeyevugol'
10. Krasnoarmeyskugol'
11. Dobropol'yeugol'
12. Artemugol'
13. Ordzhonikidzeugol'
14. Shakhterskantratsit
15. Torezantratsit
16. Voroshilovgradugol'
17. Stakhanovugol'
18. Pervomayskugol'
19. Krasnodonugol'
20. Donbassantratsit
21. Sverdlovantratsit
22. Pavlogradugol'
23. Ukrzapadugol'
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25. Ukrainian SSR Ministry of the Coal Industry



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Table 4

| (1) Производственные объединения | (2) Проведение подготовительных выработок с механизированной погрузкой угля и породы | | | | |
|---|---|---|---|---|---|
| | (3) План, км | (4) Факт., км | (5) % к общей длине проведения выработок, где требуется погрузка | (6) в т. ч. комбайнами | |
| | | | | (7) План, км | (8) Факт., км |
| (9) Донецкуголь | 233,0 | 233,2 | 79,5 | 77,0 | 77,0 |
| (10) Макеевуголь | 151,0 | 153,9 | 74,2 | 43,0 | 44,2 |
| (11) Красноармейскуголь | 122,0 | 115,5 | 75,4 | 36,5 | 36,7 |
| (12) Добропольеуголь | 165,0 | 164,1 | 96,2 | 115,0 | 110,7 |
| (13) Артемуголь | 160,0 | 160,1 | 99,9 | 10,0 | 7,0 |
| (14) Орджоникидзеуголь | 65,0 | 68,3 | 95,5 | 1,0 | 0,7 |
| (15) Шахтерскантрацит | 93,0 | 94,5 | 64,5 | 18,0 | 18,1 |
| (16) Торезантрацит | 83,0 | 84,1 | 63,1 | 9,5 | 4,8 |
| (17) Ворошиловградуголь | 122,0 | 122,0 | 76,3 | 23,0 | 21,0 |
| (18) Стахановуголь | 144,0 | 146,7 | 79,8 | 10,0 | 6,7 |
| (19) Первомайскуголь | 103,0 | 96,3 | 69,2 | 8,0 | 5,8 |
| (20) Краснодонуголь | 87,0 | 88,5 | 83,4 | 18,5 | 17,1 |
| (21) Донбассантрацит | 135,0 | 127,0 | 54,8 | 8,0 | 6,0 |
| (22) Свердловантрацит | 68,0 | 66,2 | 61,4 | 2,0 | 0,1 |
| (23) Павлоградуголь | 109,0 | 109,7 | 97,5 | 104,0 | 104,5 |
| (24) Укрзападуголь | 110,0 | 113,4 | 81,2 | 59,5 | 60,8 |
| (25) Александрияуголь | 25,0 | 25,5 | 81,0 | 25,0 | 25,5 |
| (26) Минуглепром УССР | 1975,0 | 1969,0 | 77,3 | 568,0 | 552,7 |

Key:

1. Production associations
2. Driving of preparatory drifts with mechanized loading of coal and rock
3. Plan, km
4. Actual, km
5. % of total length of driving drifts where loading is required
6. including by combines
7. Plan, km
8. Actual, km
9. Donetskugol'
10. Makeyevugol'
11. Krasnoarmeyskugol'
12. Dobropol'yeugol'
13. Artemugol'
14. Ordzhonikidzeugol'
15. Shakhterskantratsit
16. Torezantratsit
17. Voroshilovgradugol'
18. Stakhanovugol'
19. Pervomayskugol'
20. Krasnodonugol'
21. Donbassantratsit
22. Sverdlovantratsit
23. Pavlogradugol'
24. Ukrzapadugol'
25. Aleksandriyaugol'
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Table 5

| (1) Показатели | (2) План, тыс т | (3) Выполнение плана | | |
|---|---|---|---|---|
| | | (4) тыс т | (5) % к плану | (6) % к 1977 г. |
| Переработка угля на обогатительных фабриках (7) | 137770 | 133317 | 96,8 | 98,3 |
| Переработка угля на установках механизированной породовыборки (8) | 11236 | 11471 | 102,1 | 94,8 |
| Выпуск концентрата (9) | 83280 | 80753 | 97,0 | 97,8 |
| Выпуск углей крупных и средних классов (10) | 26740 | 25308 | 94,6 | 96,7 |
| В т. ч. антрацитов (11) | 19000 | 17850 | 93,9 | 95,6 |

Key:

1. Indices
2. Plan, thousands of T
3. Fulfillment of plan
4. thousands of T
5. % of plan
6. % of 1977
7. Processing of coal in enrichment plants
8. Processing of coal on units of mechanized sorting
9. Output of concentrate
10. Output of coals of large and medium classes
11. Including anthracites

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FUELS AND RELATED EQUIPMENT

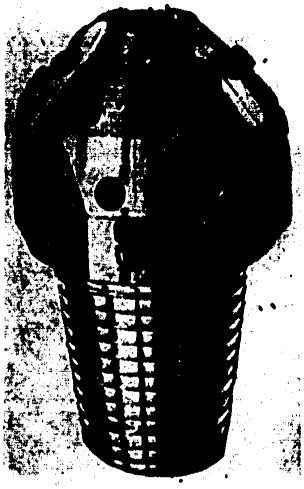
UDC: 622.24.051

BIT FOR DRILLING CEMENT PLUGS DESCRIBED

Moscow BURENIYE in Russian No 3, Mar 79 p 9

[Article by S. M. Danelyants, A. A. Loginov, and A. A. Chernik: "Bit for Drilling Cement Plugs"

[Text] Cement plug drilling is a critical operation which completes the well construction cycle. This operation frequently ends in hard-to-repair breakdowns, such as breaking of drill pipe. The main difficulty in repairing the consequences of such occurrences lies in the impossibility of either withdrawing the drill bit or destroying it during subsequent drilling due to the high strength of the materials from which bit components are manufactured. As a result it is necessary to drill a new borehole section, and this involves considerable time and money.



General View of TsP Drill Bit



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Meriting attention in connection with this is the development of a special bit which has been given the provisional designation TsP. One of the principal features of this bit is that the body is made of materials which can be easily destroyed (drilled through) with present standard bits.

TsP bits 118 and 93 mm in diameter have been built and tested by specialists at the All-Union Scientific Research Institute of Petroleum Technology and the Kuybyshevburmash Production Association. The TsP are bits of abrasive-cutting action with an aluminum alloy body into which hard-alloy teeth have been cold press-fit into mounting recesses (see photograph). If necessary these bits can easily be subsequently drilled through with standard bits.

The results of tests on TsP bits performed by the Neftegorsk Drilling Operations Administration of the Kuybyshevneft' Association as well as comparison of these bits with bits normally utilized for drilling cement plugs indicated a sufficiently high efficiency of TsP bits from the standpoint of principal technical-economic drilling indices -- footage drilled and drilling rate (see table).

| TsP Bit Number (Diameter, mm) | Number of Well on Which Test Was Performed | Total Footage Drilled, m | Total Drilling Time, Hours | Average Drilling Rate, m/h |
|---|---|---|---|---|
| 1 (118) | 52 | 196 | 38.0 | 5.1 |
| 2 (118) | 11 | 154 | 24.5 | 6.2 |
| 3 (93) | 11 | 608 | 120.0 | 5.1 |

Note: Rotary drilling was performed, with bit loading of 1.5-4.0 tons.

Work is presently in progress on determining the most efficient shapes for the working surfaces of the TsP drill bit body.

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