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2 May 1980

USSR Report

ENERGY

(FOUO 6/80)

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USSR REPORT

ENERGY

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ELECTRIC POWER

UDC 621.31.002.2

FALALEYEV ON ELECTRIC POWER INDUSTRY

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 1, Jan 80 pp 2-6

/Article by Pavel Petrovich Falaleyev, USSR first deputy minister of power and electrification/

/Text/ "...Organization, i. e., the further improvement of economic management in the broadest sense of the word, becomes the critical link."

Leonid Il'ich Brezhnev (From the financial report of the 25th CPSU Congress)

The Communist Party of the Soviet Union is giving particular attention to a unilateral strengthening of the economy, an increase in economic efficiency, and an improvement in the management of operational construction. Once again serving as evidence of this is the resolution of the CPSU Central Committee and USSR Council of Ministers adopted 12 July 1979, "The Improvement of Planning and Enhancement of the Influence of the Economic System on Increasing Production Efficiency and Work Quality."

The resolution designated the means for the further improvement of planning and management with the aim of a significant increase in the efficiency of general public production owing to the acceleration of scientific-technical progress, the growth of labor productivity, and the improvement of product quality, which, in the final analysis, should provide for a steady upsurge in the nation's economy and, consequently, prosperity for the entire Soviet nation.

Of major importance in the improvement of the economic system are the growth of the role of the state plan as the chief instrument for implementing the economic policies of the party, and the reiforcement of the plan's integral relationship with achievments in the field of science and technology.

The primary aim of all planning work is to select the most effective means for achieving high national economic results, an efficient combination of sectorial and territorial development, long-range and current plans, and also for the improvement of the intersectorial and intrasectorial ratios which ensure the balanced growth of the nation's economy.

The resolution stipulates the following procedure for drawing up long-range plans for economic and social development. The USSR Academy of Sciences, the USSR State Committee for Science and Technology, and the USSR Gosstroy are developing a complex program of scientific-technical progress over a 20-year period(in five-year segments), while the USSR Gosplan, based on the social-economic objectives and complex programs of scientific-technical progress, is developing jointly with USSR ministries and departments and councils of ministers of union republics a design of the basic directions in the economic and social development of the USSR over a ten-year period. In line with this, during the first five-year segment, plans are developed for all of the years, while during the second, the major indicators for the last year of the Five-Year Plan(in terms of capital investments for the Five-Year Plan as a whole) are formulated.

In accordance with the design of the basic directions of the nation's economic and social development, the USSR Gosplan establishes the projected figures based on basic indicators and economic norms for the forthcoming Five-Year Plan and submits them to USSR ministries and departments, as well as to councils of ministers of union republics, who, for their part, must provide for submission of the projected figures to associations, enterprises, and organizations within a month following receipt of them from the USSR Gosplan.

Complex programs in the 20-year period and basic directions in the 10-year period will be "sliding"--overlapping: they will be extended through each five years to the following five-year segment and be renewed on the basis of the latest achievments of science and technology. This will promote significant reinforcement of the role and the influence of science in planning for the development of the national economy, and will also promote an increase in the accountability of scientific and planning organizations for providing a high level of quality in the development of the plan.

Of major importance is the position with regard to the stability of the Five-Year Plan indicators by individual years, which for power industry construction means the stability of yearly plans for operational capacities, capital investments, and volumes of construction commodities production. This, on the one hand, ensures the establishment of a solid perspective in the operations of construction-installation organizations, and, on the other, becomes the limit which determines the maximum level of expenditures for the implementation of enterprises, capacities, projects in the planning stages, and for the commissioning of standard construction starts. The application of this principle will be possible only with the development of truly optimal indicators for the allocated capital investments, construction schedules, and the implementation and management of new capacities.

Fulfillment of the Five-Year Plans will be evaluated by the cumulative total for the years since the beginning of the plan. The yearly plans, being the definitive components of the Five-Year Plans, must ensure their fulfillment beyond projected figures. The evaluation of the fulfillment of yearly plans must be based on the cumulative total from the beginning of the year.

Five-Year Plans and yearly plans should be constructed on the basis of the projected figures for lower-level units(associations, enterprises, and organizations), with the active participation of labor collectives, which adopt expanded yearly counter-plans.

The resolution stipulates a strict /balance//in boldface/ in the plans for each year of the Five-Year Plan with respect to financial, material, and labor resources, and--in construction--with respect to the capacities of construction-installation organizations as well. It further stipulates that the responsibility of planning bodies for providing this balance be increased. In the event of circumstances not foreseen by the plans, ministries and departments are allowed to dump material and financial reserves. The stability of Five-Year Plans must also be guaranteed by the nonvariance throughout the plan of wholesale prices in industry, estimated prices in capital construction, and tariffs in freight transport.

The entire complex scientific-technical, economic, and social programs for developing separate regions and territorial-production complexes must become one of the basic component parts of long-range state plans for the economic and social development of the country. This has particular importance for power industry construction in that all such programs, as a rule, are based on the accelerated development of electric power.

The USSR Ministry of Power has always assigned a great deal of importance to the drawing up of long-range plans and programs. These programs bear exceptional significance for the electric power industry in view of the critical effect of electrification on the development of the productive power of the nation as a whole, as well as in connection with the capital intensiveness and length of construction time of power projects.

The inadequate working through of such long-range complex programs in the recent past is the cause of current difficulties arising in the occurrence of a fundamental change in the development of atomic and hydroelectric power, and in the use of local solid fuels, natural gas from the eastern regions, and also in the construction of powerful long-range transmission lines. The USSR Ministry of Power and the ministry equipment suppliers have turned out to be inadequately prepared to resolve all of these problems: they do not conform to the required level of development in technical documentation and equipment design. The same could be said of the capacities and technical capabilities of construction-installation organizations and the enterprises which produce this equipment.

Despite the fact that much has been done and is being done by the Ministry of Power and Electrification of the USSR in the area of establishing long-range plans, there are still serious shortcomings in the work being done on this matter. Thus, as of now there is still no clear-cut plan or program for developing and technically equipping and managing the nation's YeES/unified electric power system/, nor has the agreement been finalized with regard to long-range programs for constructing the all-important electric transmission lines and several problems in the further development of district heating in cities of the European part of the country, not to mention the development of repair facilities and enterprises of the construction industry.

Within the USSR Ministry of Power and Electrification there are serious inadequacies in providing project documentation, in the organization of construction production and shipment of structural materials, and in the supply of material-technical equipment; violations of production and state discipline are allowed to pass; the soundness of construction plans is systematically undermined. There are practically no construction projects for which capital investments could be alloted every year in accordance with approved title lists(there have even appeared such terms as, "floating titles"). This occurs both because of the reduction in overall capital investments alloted to the ministry(compared with those approved in the Five-Year Plan), and because of a systematic failure to complete the majority of construction starts in the established yearly work volumes. But despite this, construction of a number of new projects gets underway each year. Thus, in 1978, 23 construction projects were started for electric power stations alone, of which 20 did not fulfill the plan; in 1979, 17 construction projects were started, but 15 did not fulfill the work plan within eight months.

As a result, a completely intolerable situation is created, wherein construction of the majority of projects is not completed within the normal schedule, and the length of time needed for constructing projects and establishing capacities increases unconscionably. For example, thermoelectric power stations are now being built in an average time which is one and a half times longer than the scheduled time period. The completion of work on a number of GES's now on-line was delayed due to insufficient allocation of capital investments for these purposes.

The total surplus of estimated expenditures for electric power stations operated at full capacity amounts to around 450 million rubles--nonetheless, up to 120 million rubles is allocated each year for the completion of construction of these power stations, and this sum is distributed among numerous projects(in amounts of 250,000 to 500,000 rubles, and, at best, one to one and a half million rubles), and the plan for 1980, unfortunately, did not manage to avoid such distribution.

The off-schedule implementation of power capacities leads, as we know, to an increase in the amount of unfinished construction and to the freezing of capital investments without an increase in preparedness for project starts. For example, the delay in activating the power-blocks of the Kursk and Novovoronezh AES's in 1978 led to an increase in unfinished construction amounting to 240 million rubles by January 1, 1979, while the overall cost of the failure to fulfill assignments related to the implementation of fixed production capital last year amounted to 1.3 billion rubles.

Uncompleted production within construction organizations for the USSR Ministry of Power as a whole amounts to three billion rubles, in fact, for the first three years of the current Five-Year Plan, it increased by 1.1 billion rubles. It should be taken into account that every fourth ruble of this overall sum was generated at the direct fault of the builders themselves, which in the main is a result of distributing equipment and resources to a great many projects on internal-construction title lists. For USSR Ministry of Power titles alone, the number of projects simultaneously undergoing some phase of construction grew from 8,200 to 11,800, i.e., by 40 percent, in the first three years of the current Five-Year Plan.

The problem of balance in the plans remains a matter of urgency. The performance in this area by the functional subdivisions of the USSR Ministry of Power--GlavPEU/Main Administration for Economic Planning/, Glavniiproyekt/Main Administration of Scientific Research and Planning Organizations/, Glavsnab/Main Administration of Material and Technical Supply/, Glavenergokomplekt/Main Administration for Supply of Electrical Equipment for Electric Power Stations, Substations, and Networks/, Administration of Worker Cadres, Administration for Labor Norms and Wages, Main Technical Administration, Fuel Transportation Administration, and Financial Administration--cannot be regarded as satisfactory, insofar as the ministry as a whole, as well as its production and construction subdivisions, are experiencing serious difficulties in providing material-technical equipment and supplies. This situation was to a great extent engendered by the unsatisfactory technical substantiation of the norms and plans for all types of support, starting with project documentation. This development is fully related to the balance of labor resources; it will suffice to point out that the current shortage in the labor force for power industry construction is roughly estimated at 40,000 people.

Plans for economic and social development have been augmented by new special sections detailing a broad range of measures in the area of social development, which are aimed at improving labor conditions, raising worker qualifications, improving living conditions and cultural lifestyles of workers, and including plans for raising the technical standard of the sector, which call for the introduction of new high-quality goods and materials, progressive technology, an improvement in production quality, and measures for preserving the environment. The insertion of these new sections naturally requires a substantial reworking of the planning system with the involvement of Glavniiproyekt, the Main Technical Administration, GlavURS/Main Administration of Worker Supply/, and a number of other subdivisions of the USSR Ministry of Power.

The resolution introduces substantial changes in the basic indicators of plans both in industrial production and in capital construction. The work of each enterprise in the industry will now be rated, not according to gross output, but according to such specific indicators of an organization's performance as net production increase, the filling of specific orders from consumers, etc. While for construction these indicators will be: putting on line production capacities and projects, volumes of deliveries of construction commodities, as well as levels of labor productivity and profits. The introduction of this system of indicators will permit a more goal-directed orientation of the operations of construction subdivisions in terms of completing construction projects, and an objective evaluation of their individual contributions toward increasing the efficiency of the sector.

The most important change in the system of industrial planning indicators is the conversion to planning production output in natural standards of measurement. Accordingly, the method of working out planning objectives "from past accomplishment" is being replaced by more precise engineering estimates with the introduction of new highly efficient standards for the expenditure of resources in the output of finished production.

We shall not dwell on all of the indicators of industrial production plans(they are elaborated in detail in the resolution), especially since with respect to power production it was specified in paragraph 10 of the resolution that, in view of its special nature, authorization be granted to establish other indicators which more exactly reflect the dynamic of production, the increase in its efficiency, and the growth of labor productivity.

The present operational system of planning indicators in the power industry has proved to be contrary to the objectives of a maximal economy of fuel-power resources, as well as to the operations of the power enterprises which make up the YeES of the country. This gives rise to a great many corrections of the production plans of power systems, electric power stations, and network enterprises involving all indicators, which quite frequently is employed to cover up inadequacies in their operations.

The special urgency and sensitivity of this problem is made clear in the fact that the resolution obliges the ministry to ensure the stability of yearly and quarterly plans, not permitting them to be modified by lowering the current level of their fulfillment. Strict accountability for such modifications has been instituted at all levels of management.

The resolution stipulates that the USSR State Committee for Science and Technology, together with other interested ministries, issue during the period 1979-1980 an appraisal of the technical level of equipment being produced, with the aim of developing measures to increase its technical-economic indicators and to remove obsolete products from production.

The technical administrations, Glavniiproyekt, Glavenergokomplekt, Glavenergostroymekhanizatsiya/Main Administration for Mechanization of Construction/, and scientific-research institutes must take the most active participation in this effort, the results of which will have tremendous importance for improving the quality of power-gnerating and electrotechnological equipment supplied by the power-machine-building enterprises.

The resolution stipulates the makeup of the USSR Gosplan, along with the USSR Gosenab and ministries representing a territorial balance of production and distribution of the most important kinds of products. According to the USSR Ministry of Power, it is essential that this situation be exploited for a proper territorial distribution of limits on the consumption of electric power according to the sectors involved, which is very urgent in connection with the certain degree of tension existing in the fuel-power balance.

The resolution has devoted much attention to matters having to do with the improvement of capital construction. As was noted at the 25th CPSU Congress and subsequent plenums of the CPSU Central Committee, as of yet there are still serious shortcomings manifested in the capital construction sector, which are reducing the effectiveness of capital investments and the whole of general public production. Normative and planned time schedules for construction and on-line activation of production capacities and projects are being upset and material supplies and equipment are being scattered while the volume of uncompleted work is increasing.

An increase in the effectiveness of capital investments, a qualitative growth in fixed capital, and an acceleration in the on-line implementation and management of power capacities all take on special importance with the growth in the dimensions of building production.

The resolution has supplied specific recomendations for improving the planning and control of capital construction and for reinforcing economic estimation and economic stimulation with the aim of rapidly achieving finished results in construction operations.

Principally, the new procedures are:

planning for on-line implementation of power capacities to be done by the subcontracting organizations which are carrying out the installation of up-dated equipment;

a gradual transition in the 11th Five-Year Plan to planning for labor productivity in construction-installation organizations based on net(normative) production or some other indicator which more exactly reflects the change in the labor wage structure, while planning for wage assets will be based on the norm per ruble of production cost;

the completion in 1981 of a transition to the making of estimates among customers and contractors based on fully completed and operational construction starts of complexes, sections, and projects made ready for production output; in line with this, the expenditures of contracting organizations on uncompleted production of construction-installation work will be carried only at the expense of banking credits;

a transition to the making of estimates among design-developmental organizations and their customers based on completely finished designs for construction of enterprises and construction starts of complexes, sections, and projects;

the issuance of orders to ministry-manufacturers for the supply of basic technological and power-generating equipment for the entire period of construction, and for the supply of metal structures for construction for no less than two years; accordingly, orders(authorizations)for equipment supply issued by the USSR Gossnab will remain in effect until their complete execution.

Moreover, in order to ensure the operational continuity of capital construction plans, the approved title lists will become unmodified planning documents for the entire construction period, and beginning with the 1981 plan, a new time period for submission of operational designs is being established: up to July 1st of the year preceding the plan year(the previous deadline was September 1st).

Unfortunately, at the present time, about 15 percent of the yearly volume of operations is not covered by documentation--even by September 1st, while for certain complicated projects, the situation is even worse. This particularly is true for atomic power stations. Thus, at the September 1st deadline in 1978, only 70 percent of construction on the Chernobyl'skaya AES was covered by technical documentation; 40 percent at the Balakovskaya AES, and 20 percent at the Krymskaya AES. The situation with the development of documentation for construction of high-tension electric power transmission lines is no better.

In particular, it should be noted that resources for the construction of new enterprises and the expansion of existing ones will now be allotted only in cases where the demands of the national economy for a given type of product cannot be met by the existing enterprises with allowances for their reconstruction and technical modernization. Therefore, planning balance sheets and estimates related to the use of existing production capacities and fixed capital, as well as summary plans for the technical up-grading of enterprise equipment must be developed within the design framework of ministerial and departmental five-year plans. The means to these ends must be set forth as a first priority.

The distribution of construction-installation work volumes according to a construction schedule will be handled jointly by customers and contractors owing to the necessity for ensuring that contracting organizations operate on a rythmic basis and for establishing a technological stockpile with an eye to the standards for the length of construction time. The time limit for the completion of construction remains unchanged. The failure to fulfill a yearly plan must be compensated in the following year at the expense of surplus material resources of the contractors and reserves of the ministries. This situation requires serious administrative--and even psychological--restructuring.

Currently, design institutes of Glavniiproyekt are allowing serious overestimates in the evaluation of the projected cost of power projects under construction. Thus, during the years 1976-1978, there occurred a cost overrun in the estimates for projects under construction amounting to more than one billion rubles, including 400 million rubles for hydroelectric stations and 300 million for atomic.

The USSR Gossnab has been charged with completing in 1981 the transition of construction projects to a complex supply system which draws materials from USSR Gossnab territorial organs filling orders from construction-installation organizations. The importance of design for a proper determination of the requirements for equipment, materials, and structural members will become crucial in this respect--a fact which is being underestimated at present. As an example, there is the less than satisfactory situation with the development of new standards for the use of metal in electric power transmission lines: estimates worked out from designs of Energoset'proyekt/Main Technical Administration for Construction and Design of Electric Power Stations, Substations and Grids/have been returned repeatedly for modification.

Even now, serious errors are being permitted in the compilation of specifications for requisite materials, equipment, and structural parts.

The resolution calls for serious measures to improve material-technical supply to the construction industry. This primarily concerns the problem of standardizing the delivery of foreign supplies. However, this does not mean that one can expect to obtain resources on the basis of poorly substantiated requisitions. Planning balance presumes the supplying of resources only on the basis of their efficient use and unconditional adherence to standards for consumption, for surpluses, and for inventory control, as well as for the proper distribution of resources.

In view of the fact that power industry construction is shifting over now to industrial methods, which means that to a large extent it is becoming dependent on deliveries of structural parts from construction industry plants, it is incumbent upon the ministry to assure the conformity of the intersectorial material-technical construction supply system to the requirements of the resolution.

Serious shortcomings still exist in this important area. Time schedules for the delivery of structural materials are being disrupted and, with the emphasis on production volume, the coordination of deliveries is upset, particularly as a result of the fact that the delivery of structural parts to the construction site is accomplished from several different plants. Thus, as of September 1, 1979, power station construction sites had been undersupplied by 20,000 cubic meters of precast reinforced concrete, even though a ministry order had specified completion of these deliveries by August 1; power stations under construction had been undersupplied by 27,000 cubic meters of precast reinforced concrete and 10,000 tons of metal structures. For power transmission lines and substation construction projects, 74,000 cubic meters of precast reinforced concrete had been undersupplied.

As a result of the incomplete delivery of structural components, a number of SMR/construction-installation work/schedules have been disrupted and major unwanted surpluses of precast reinforced concrete(1,368,000 cubic meters) and metal structures(181,000 tons) have been built up; there has been a freeze on deficit material resources.

It is incumbent upon Glavenergostroyprom/Main Administration of Plants and Production Bases of the Construction Industry/, Glavenergostroymekhanizatsiya, and other main administrations of the construction industry which are the suppliers of structural components to adopt drastic measures to forestall the occurrence of similar such statistics.

It goes without saying that the timely and complete supplying of structural components to construction projects largely depends on the transportational scheme used to move them. The tendency in recent years to specialization in construction industry plants is leading, in certain cases, to an increase in shipping distances.

The main condition for fulfillment of the resolution is a strict adherence to state discipline and production standards(this applies to capital construction as well), and, above all, to planning procedures. Within the USSR Ministry of Power, the performance in this area is still not fully satisfactory. Thus, in the 1979 effort to lower specific fuel consumption(in the conversion to conventional fuel) by 2.1 g.--after eight months, the actual reduction totaled 0.6 g.

It is commonly known that the timely on-line activation of power capacities has great importance, in equal measure both for the elimination of gaps between the rated capacity and the available capacity of power stations, and for the reason that this amounts to the acquisition of additional capacities. The present situation with respect to this matter could not possibly be called satisfactory.

The forthcoming economic reorganization is aimed at all administrative and planning activity, as previously indicated, in an effort to obtain higher end results. The success of the construction industry is to a significant extent determined by its proper technological preparedness and organization.

The resolution obliges the ministry to develop and implement specific measures to improve capital construction control, by means of which conversion will be effected to a two-three-stage system of control during 1979-1980. Of course, the USSR Ministry of Power has been directing itself to this matter for several years now, but to date has not completed its work. One cannot, for example, regard as normal the existence of about 300 small contracting organizations with an annual work volume amounting to one to two million rubles apiece, half of which systematically fail to carry out planning objectives, according to basic economic indicators.

The resolution has devoted considerable attention to matters related to the further development the economic estimate and enhancing the role of economic levers and stimuli in the area of industrial production control and capital construction control.

Development of the economic estimate is called for on the basis of reliable indicators and economic norms of the five-year plan. There is an increase in the role of qualitative indicators in the formation and utilization of capital for economic stimulation. Much importance is attached to the development to a system of economic norms relative to planning for and stimulating production, including norms for the distribution of profits. Provision is made for strengthening the stimulative role of the common fund for the development of science and technology, which was established in ministries and departments to be paid for out of their profits. This very important measure was aimed at the stimulation of the activities of the scientific sector, the strengthening of its ties with the production sector, the rapid introduction and application of every scientific and technical advance, as well as promoting the fulfillment of national economic plans and the achievment of higher end results from production. In connection with this, there will be an increase in the accountability of functional subcontractors of the USSR Ministry of Power, as well as design, scientific-research, and regulatory agencies for the timely and well-planned development of progressive standards and for the compilation of passports for enterprises and production associations.

A major role in the resolution is given to problems related to increasing labor productivity, all means of economy and efficiency in the use of labor resources. It was deemed advisable to establish a limit on the size of the labor force, as well as to reaffirm the objective of reducing the amount of manual labor. This is a very serious problem, bearing direct significance for power industry construction workers: in fact, in construction alone, more than 200,000 workers are involved in manual labor.

In order to improve the use of labor resources and stimulate the growth of labor productivity, a new procedure is established for paying off surcharges to tarrif rates and tax rates at the expense of economy in the wage fund.

The resolution called for an increase in the size of bonuses for the timely on-line activation of power capacities and for a reduction time needed for activation.

The brigade methods of organization and wage payment will receive further development. Unfortunately, this progressive type of organization of labor is inadequately employed in ministry subdivisions--as yet, only about 20 percent of the SMR volumes performed are covered by it.

Thus, in the light of the objectives put forward by this new resolution of the CPSU Central Committee and the USSR Council of Ministers, the USSR Ministry of Power must, in the near future, promote efforts for the effective improvement of power industry construction.

It is essential that:

GlavPEU, Glavniiproyekt, GPTU/Main Industrial-Technical Administration/for Construction, Glavsnab, the Administration of Cadres, and the Financial Administration--ensure strict balance in yearly plans according to financial, material, and labor resources and according to the capacities of construction-installation organizations;

Glavniiproyekt, the Scientific-Technical Council, the USSR TsDU/Central Dispatch Administration/of the YeES, and the Energoset'proyekt Institute--complete as soon as possible a review and coordination of the long-range trends in the development of the nation's electric power status and the plan for the development of YeES in the USSR, and also to develop a program for its technical improvement;

GlavPEU, Glavtekhupravleniye/Main Technical Administration/, GPTU for Construction, and the Main Construction Administration--guarantee for construction projects the fulfillment of yearly work volumes established by state plan; single out those power stations undergoing installation work, which must be afforded the means for full completion of construction work, and wherever such need is not indicated, move decisively to close out the estimates;

GlavPEU, Glavtekhupravleniye, the Administration for Labor Norms and Wages, and the Financial Administration--urgently organize the development of supplies according to new indicators for the electric power industry;

Glavenergostroyprom--at the start of 1980 convert to the fully integrated supply of and centralized payment for structural components intended for electric power grid construction, and at the start of 1981 expand this system to supply structural components for AES;

Glavniiproyekt, GPTU for Construction, Glavteploenergomontazh/Main Administration for Installation of Thermal Power Equipment for Electric Power Systems/, and their institutes--convert to releasing design-estimate documentation by July 1 of the year preceding the year in which the work is done; provide, on a timely basis, for the inclusion in design drafts of data on the requirement for materials, structural components, and parts for the entire period of outfitting of projects broken down by years; beginning with 1981, stipulate the development of standardized technological complements of precast reinforced concrete structures in design drafts;

Glavenergostroyprom, Glavenergostroymekhanizatsiya, GPTU for Construction, and the Main Construction Administration--carefully analyze existing methods for shipping structural components and develop effective measures for optimizing these methods.

Improvement of the economic system manifests itself within the fierce struggle to fulfill the objectives and socialist committments of the 10th Five-Year Plan. There is no doubt that the personnel of the Ministry of Power and Electrification will do everything necessary for the realization of measures outlined by the party and the government, and by the same token, will make a heavy contribution to the further consolidation of the power of our socialist homeland!

Publisher's note: With regard to the urgency of the issues raised in the resolution of the CPSU Central Committee and USSR Council of Ministers, "The Improvement of Planning and Enhancement of the Influence of the Economic System on Increasing Production Efficiency and Work Quality," we are beginning to publish materials devoted to the objectives of USSR Ministry of Power subdivisions and organizations in light of the above-mentioned resolution. The editors request that readers and authors actively participate in a discussion of the issues touched upon in this resolution.

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ELECTRIC POWER

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CONSTRUCTION ORGANIZATION OF ATOMMASH

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 1, Jan 80 pp 7-9

[Article by Eng Ye.A. Bazhenov: "Construction Organization of Atommash"]

[Text] From the Editors: The first stage of the gigantic nuclear-power machine-building plant, Atommash, is being prepared to produce its first output. In connection with the special nature of this facility an entire complex of organizational and technical problems was solved during its construction. The group of builders accumulated valuable practical experience in erecting technically complicated facilities under unfavorable engineering and geological conditions. The selection of articles which is being published, illuminating the advanced practical experience of the Atommash workers, is certainly attracting the attention of our readers--the builders of electric power stations.

During the next few years the principal increase in nuclear electric power capacity must occur by means of increasing the integrated capacity of electric power units (1000 MW and more) at newly built AES's. In order to industrialize the construction of such electric power stations, we need to create specialized machine-building enterprises engaged in producing basic and auxiliary equipment for AES's. The practical realization of the plan to develop nuclear electric power engineering began with the construction in the city of Volgodonsk, Rostovskaya Oblast, of a machine-building plant to turn out electric-power and auxiliary equipment for the Atommash AES. This plant's annual productivity is eight sets of equipment with a capacity of 1 million kW each.

The plant's construction has proceeded in two stages. It is planned to carry out the introduction of the plant's capacities in three steps (the first start-up complex, amounting to three electric-power sets for the AES, was introduced in 1978).

The Volgodonsk Atommash Plant is the largest (in our country or abroad) custom built complex of specialized workshops with a complete production cycle for manufacturing equipment for nuclear electric-power stations. With regard to the volume of output being produced it is among the top 3--5 percent of the country's particularly large enterprises.

This plant includes six principal production wings with a total area of 730,000 sq. m. The largest of these are Wings No. 1 and 4, with areas of 280,000 and 200,000 sq. m respectively. In their technical equipment and construction parameters they are unequalled among machine-building types of enterprises.

Located in Wings No. 1 and 4 is specially made domestic and imported equipment, designed to make the housings of reactors, steam generators, water storage units SAOZ /expansion unknown/, volume compensators, steam separators, VKU /water and waste disposal/equipment, primary-loop heat-exchange equipment, bioprotection systems, and transport apparatus.

Wing No. 1 consists of a rectangular building with a floor plan measuring 744×393 m and a maximum height (to the lower girder zone) of 40 m. Taking into consideration the specific characteristics of the production technology, as well as the scale dimensions of the equipment to be located in this wing, the spans in it were adopted as equal to 30 and 42 m, with column spacing as 18 and 36 m. In connection with the above-indicated dimensions of the building itself and the necessity for using within it cranes having a large load-hoisting capacity (up to 1200 tons), the vertical load capacity on individual sections of the footings amounts to 500 kN with a moment of 200 kN. m; this is 5--10 times higher than the load capacity on the footings of existing machine-building plants.

Wing No. 4 has a floor plan measuring 558×363 m, the maximum height to the lowest girders reaches 48 m, and the span length is 42 m.

Wing No. 2 has been designed basically to manufacture SUZ (Central Urals Plant) drives, while Wing No. 6 is to manufacture special welding electrodes and fluxes. Wings No. 3 and 5 have ancillary purposes: they will produce non-standard equipment, instruments, and the like.

In order to ensure the technological needs of the plant, a number of large electric-power supply facilities are also being built (Volgodonskaya TETs-2), GPP's /Main Step-Down Substations/ with 110-kV electric-power transmission lines, water-supply systems with a water-isolation unit from the Tsimlyansk Reservoir and water-purification structures, a water-circulating unit, and a complex of drainage facilities with water-purifying sewerage structures. The creation of an industrial enterprise is inextricably linked with the construction of a large number of non-productive types of facilities. Thus, we are faced with the task of erecting apartment houses with a total area of 1,600,000 sq. m, with a complete complex of cultural and domestic facilities; we must create an industrial-community zone. A considerable amount of construction work at the Atommash plant has to be carried out within compressed time periods.

The principal physical amounts of work comprise the following: 75, 980,000 cu. m of excavation and earthwork, 5,760,000 cu. m of monolithic concrete laying, 2,782,000 cu. m of installing precast reinforced concrete (including 1,260 cu. m of industrial), 369,000 tons of installed metal structural components, 717,000 cu. m of bricklaying, and 3,896,000 sq. m of roofing installation.

Our country has accumulated a great deal of experience in the rapid construction of large industrial facilities (for example, such giant complexes as the Volga and Kama Motor-Vehicle Plants). At Atommash, the construction of which has been entrusted to the USSR Ministry of Power and Electrification as the general contractor and the USSR Ministry of Installation and Special Construction Work as the principal subcontractor, this experience was adopted as a basis; however, under the conditions of the city of Volgodonsk it was developed further.

The principal structural unit at the plant construction site is the general contracting Volgodonskenergostroy Trust, which was created in May 1975 on the basis of the Volgodonskpromstroy Administration The newly formed trust, like the installation subdivisions, was confronted with a complex task--to develop production capacities at a rapid rate and to create a group capable of carrying out its assignment with regard to the construction of the leading nuclear electric-power machine-building plant within the established time periods. In order to successfully solve this problem in the first stage, an enormous amount of work was carried out by the trust's supervisors and its social organizations with the rendering of continuous aid from the leadership of the USSR Ministry of Power and Electrification, along with that of the Party organs of the city of Volgodonsk and Rostovskaya Oblast. Coming to the construction of Atommash were workers and engineers from analogous construction projects of the USSR Ministry of Power and Electrification, workers sent in the form of organized, recruited groups from various regions of the country, others who were comandeered from Rostovskaya Oblast, Komsomol construction detachments, and so forth (No small role was played in attracting people to this construction site by the privileges which were granted to the builders of Atommash). During a period of 2.5 years the population of Volgodonsk more than tripled and at the present time amounts to over 100,000.

Thus, one of the complex problems was the distribution of personnel. In order to resolve it successfully, along with the speeded-up construction of apartment houses as major projects in the city of Volgodonsk and the settlement of Krasnyy Yar, temporary residential settlements were built of PDU (Production Road Administration)-type houses.

Office areas of the city's enterprises have also been utilized as temporary dormitories. It should be noted that there was a precipitous growth in the operational load of the public-dining enterprises, municipal trading posts, and other organizations.

Amid such a rapid growth in the group of builders there arose definite difficulties in solving the problems of organizing construction operations at the site. It was necessary to organize the training of workers who did not have construction specialized skills, to form brigades, sections, an SMU (Construction and Installation Administration), to begin the construction of everyday-service facilities and base areas, while at the same time inaugerating the construction of the plant's main wings, as well as apartment houses and cultural-domestic facilities. Of great importance at this step was the practical experience of the engineers and technicians who had passed through the "schools" of the VAZ (Volga Motor-Vehicle Plant), KamAZ (Kama Motor-Vehicle Plant), and the country's other construction projects.

In 1976 construction and installation operations were already carried out to an extent valued at 114.5 million rubles, i. e., 3.8 times more than in 1975. The plant's production wing No. 3 and the hot-water boiler were put into operation; the plan for housing construction was over-fulfilled by a considerable amount. During the years following the amounts of work accomplished by the trust grew intensively: in 1977 by 24 percent, in 1978 by 15 percent; in 1979 a 42-percent increase (as compared to the 1978 level) in the volume of work was provided for.

The increase in the construction growth rate occurred along two main lines: erection of basic facilities on the site of the Atommash Plant and the construction of non-production facilities in the expanded southwestern and new micro-districts of Volgodonsk. Step by step the following were built and put into operation: water-purification structures with a throughput capacity of 75,000 cu. m per day and waste-water-purification structures.

Two power units were put into operation at TETs-2 ahead of the planned time periods. All this allowed energy resources to be ensured for the construction of the plant and the city. During the years 1976--1977 some 525,000 sq. m of housing were built, along with 10 kindergartens with accomodations for 2,560 children, three schools with places for 3,070 pupils, two polyclinics, and a number of other facilities.

The physical volumes of construction and installation work completed are cited in the table below on a year-by-year basis.

Operations	1976	1977	1978	1979 (8 mos.)
Earthwork (in mil. cu. m)	6.3	7	9.1	7
Laying monolithic concrete and reinforced concrete (in thou. cu. m)	432	463	635	503
Installation of precast reinforced concrete (in thou. cu. m)	177	235	257	190

Erection of brick-laying work (in thou. of cu. m)	51	60	76	55
Installation of metal structural components (in thou. of tons)	51	48	46	49

The daily volume of concrete laying during the summer exceeded 4,000 cu. m. The maximum completion of construction and installation work per month reached 21.6 million rubles in construction as a whole, including 18.2 million rubles on the Atommash facilities.

The year 1979 was also characterized by further expansion in the volume of construction production. During the first nine months of that year an amount valued at 117.8 million rubles of construction and installation work was completed, which is 17 percent more than the volume of work completed during the same period of 1978.

At the present time the efforts of the builders are directed at ensuring that in 1980 production of electric-power equipment for the AES will amount to a capacity of 1 million kW. For all practical purposes this will complete the construction of the first stage of the Atommash Plant.

At the present time the trust includes the following: seven construction administrations, which have under their jurisdiction 25 construction and installation administrations, a motor-vehicle production association, a production and technological administration, the ZhKK (Housing and Community-Services Office), an energy section, and a service for the construction and operation of communications networks. The subcontracting organizations of the USSR Ministry of Power and Electrification, the USSR Ministry of Installation and Special Construction Work, and other ministries have at the construction site individual cost-accounting sections and construction-installation administrations. A total of 30 subcontracting organizations are taking part in the construction.

In view of the large number of participants one of the basic principles of operational organization is the specialization of subdivisions by types of operations and objects of construction. Thus, the principal amount of earth work is being carried out by the Administration for the Mechanization of Construction Operations, the laying down of engineering networks and roads has been entrusted to the Promstroy-2 Construction Administration, finishing operations at the industrial facilities are performed by the Otdelstroy Construction Operation, while the Zavodstroy and Promstroy-2 Administrations are engaged in erecting the basic types of facilities for the plant and the industrial base. In order to speed up the completion of operations on the power-engineering facilities, the Atomenergostroy Administration was created in 1979. Subcontacting organizations have also specialized as to types of operations (for example, the Yuzhstal'konstruktsiya Trust of the USSR Ministry of Installation and Special Construction Work is carrying out the installation of the principal mass of metal structural components of the wings, the entire amount of the roofing operations is being done by the Spetspromstroy Trust, and so forth). Since 1979 the entire cycle of operations involved in building the apartment houses and cultural and domestic facilities has been performed by the DSK (Home-Building Combine)-7 of the All-Union Soyuzatomenergostroy.

The system which has been adopted for the specialization of the construction organizations has facilitated the operative and efficient administration of the construction project, heightened the responsibility for adhering to the time periods for operational production, and it has a positive influence on their quality.

The construction of this plant is being carried out in tandem with the creation of an industrial base for the construction organizations. In 1975 the construction project's Pioneer Camp was established, designed to carry out operations amounting to 15 million rubles per year. During the last few years the capacity of the construction camp was increased to 70 million rubles. At the present time facilities of the construction camp's second stage are being built; after their introduction into operation (in 1980) its capacity will grow to 200 million rubles.

During the initial construction period in Volgodonsk there were not the necessary capacities for turning out precast reinforced concrete either for industrial or for civil construction. The construction project has been supplied with items shipped in from all parts of the country. The slogan "Atommash is being built by the entire country" has found its embodiement primarily in the delivery of plant-manufactured structural components and items. The overwhelming majority of ministries and departmental suppliers have coped with the task of organizing precise deliveries to the construction project. A great deal of work along these lines is being conducted by the territorial organs of USSR Gossnab--the UMTS (Material and Technical Supply Administration) of the Northern Caucasus Region.

At the same time it must be noted that the use of materials shipped in from the outside brought about difficulties among the builders. Thus, for building up the municipal districts obsolete series of houses were sometimes delivered; they did not correspond to the architectural needs of the project and hindered the comprehensive build-up of the districts. Moreover, the multiple loading and unloading of items during the transportation process inevitable leads to a worsening of their quality.

In connection with this, 1979 witnessed the building of a large-panel home-construction plant with a capacity of 140,000 sq. m of housing per year. A stepped-up rate is being used in the construction of a second, additional plant, engaged in producing keramzit-gravel panels. Construction work is nearing completion and preparations being made to put into operation a ZhBI (Reinforced Concrete Items) plant with a productivity of 100,000 cu. m per year and a plant turning out metal structural components with a productivity of 20,000 tons per year. Construction work is beginning on a silicatematerials plant. The putting into operation of these enterprises will allow us to fully guarantee to the construction a supply of the necessary items of local production.

One of the characteristics of the Atommash project is the introduction of the method of parallel planning and construction, a method which was tested earlier on other construction projects. Provisions are made for working out the TEO (Technical-Economic Grounds) and working drawings without issuing an engineering plan and, consequently, without a plan for the construction organization. Moreover, during the period when the first stage of the plant was being carried out, there was a re-planning of a number of Wing No. 1's workshops for the purpose of increasing their planned capacity. All this led to definite difficulties in ensuring production with engineering documents. The compressed time periods for construction, the participation in it of a large number of subcontracting organizations, the unusual nature of the structural elements of the wings, footings, and underground system required certain changes in the character of the work of the technical services of the builders with regard to the engineering preparation for production. The lack of a plan for the construction organization compelled the builders to increase the volume of PPR (Operational Production Plans) on the spot, including within them elements of POS /expansion unknown/ when necessary. Also drawn into this work were the specialized planning institutes of Gidroproyekt and Orgenerostroy of the USSR Ministry of Power and Electrification, as well as the planning institutes of the USSR Ministry of Installation and Special Construction Work. From 1975 through 1977 alone the Gidrproyekt Institute, which was the general planning office with regard to the construction organization, as well as its subcontracting planning organizations, worked out the documentation with regard to the engineering preparation to an extent valued at 755,000 rubles. The total amount of planning operations concerned with the engineering preparation for the construction of the plant's facilities up to 1983 will come to about 3 million rubles.

It should be noted that the custom-built quality of the Atommash plant's wings brought about the necessity of utilizing new types of structural components, building materials, and methods of operational production. In particular, in connection with the fact that the plant's wings are being erected on shifting soils of Type No. II, the planners and builders were confronted with complex tasks with regard to selecting structural components and a method for installing the foundations. It was decided to utilize foundations on drill-compacted piles, which allowed a comprehensive solution to a number of very important problems, such as the transfer of large loads to the soil base, the reduction in the amount of earthwork, a raising of the level of the production standards, and a decrease in the construction time periods. The drilling operations were performed by specialists of Gidrospetstroy of the USSR Ministry of Power and Electrification. Thanks to the high quality of the operations, this solution turned out to be very effective.

The metal structural components of the principal wings are being erected with the use of the progressive method of large-block installation. This method may be used for the installation of enlarged blocks with a maximum area of 540 sq. m and a weight of as much as 120 tons; moreover, a complete outfitting of the block is carried out with appropriate elements of ventilation systems, electric supply, and roofing. Unfortunately, further increase in the volume and weight of the structural components being hoisted up are restrained by the technical capabilities of the existing crane equipment.

The exterior walls and roofing of the plant's main wings are made of lightened, three-layer wall panels of the "sandwich" type, as well as a profiled frame with heat insulation of mineral-wool panels. Such a solution allows the maximum mechanization of operations and a reduction of their duration. However, in connection with the fact that the "Elektroshchit" Kuybyshev plant until now has still not mastered the technology of introducing a fireproof additive to the polyurethane foam in manufacturing the "sandwich" panels, it is often necessary to install in places where the fire danger is particularly great panels made of keramzit concrete or to erect a brick lining.

In the installation of an interior technological zero cycle in Wing No. 1 special measures and technical developments had to be carried out. The need for this was explained by the fact that the building's framework had already been erected, while the footings under the equipment were laid at a great depth. It was decided to install drill-compacted piles (at the construction project this method was designated as the "pile wall in the ground"). The organization of work on constructing the technological zero cycle in the wing according to the principle of the technological flow, as worked out by the Gidroproyekt institute, allowed the on-schedule beginning of the installation of the equipment in the wing.

Also deserving of attention is the experience in organizing the mechanized operations. The principal types of machines are concentrated at the present time in two administrations: in the USMR (Inter-Regional Construction Administration) (heavy machinery for the production of earthwork and crane equipment) and in the UMM (Local Machine-Building Administration) (the principal part of the means for small-scale mechanization). Such a specialization allows the achievement of a rational utilization of machines, as well as finding new ways to raise the level of mechanization and labor productivity. For example, it turned out to be very effective to create mechanized complexes for the production of earthwork; they include machines for loosening, working, transferring, and compacting soils, as well as dump trucks. Such brigades have become a fine basis for introducing brigade subcontracting in transport.

The volume and nomenclature of operations being carried out by the Administration of Small-Scale Mechanization are constantly expanding. In 1977 it amounted to 2,768,000 rubles, and in 1979--4.2 million rubles. Concentrated in the UMM are the means of mechanization with more than 400 designations (over 16,000 units). In August 1979 an All-Union school was conducted in Volgodonsk on studying progressive experience in mechanizing finishing operations; it affirmed the correctness of the construction trend selected with regard to the question of mechanizing operations.

In the construction of Atommash great importance is attached to the development of socialist competition. The administration, Party, and trade-union organizations are constantly working to improve the forms of competition and to increase its effectiveness.

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OVERVIEW OF CENTRAL HEATING

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[Article by Ye. I. Borisov, USSR first deputy minister of power and electrification, and V. P. Korytnikov, director of the All-Union Scientific Research and Planning Institute of the Power Industry]

[Text] In 1970-1977, the world consumption of fuel and energy resources increased approximately 3.3-fold, and more than 6-fold in the USSR during the same period.

In the USSR, just as in the majority of large industrially developed countries, about 95% of the consumed energy is produced by burning organic fuel.

In the USSR, hydropower engineering satisfies about 3.5-5 percent of the total needs in energy, and atomic energy accounts for less than one percent.

The program for the construction of atomic electric power stations which is being developed and implemented in our country is expected to satisfy almost completely the entire increment of electric power needs within the limits of the European part of the USSR. However, even after the implementation of this program, the share of AES [nuclear electric power stations] in the overall fuel and energy balance will increase only to 10-11%. Thus, organic fuel will remain to be the basis of electfic power supply practically to the end of this century.

At the same time, the steady growth of fuel consumption will result in a rapid depletion of the known reserves of the best types of fuel, such as oil and gas, and a simultaneous increase in the capital intensity of the branches of the fuel and energy complex.

As the economy of the Soviet Union develops, more and more attention is given to the problems of the rationalization of production and the distribution and consumption of energy. Under modern conditions, this problem is of primary importance for the entire scientific, technical, and economic activity of the country.

At the December Plenum of the CPSU Central Committee of 1977, Comrade L. I. Brezhnev stressed that among large-scale intersectorial problems nothing is more important than the fuel and energy problem.

A special place in ensuring further reliable power supply to the national economy belongs to two main forms of energy: electric and thermal (of medium and low potential). Our country spends about 60% of primary energy resources on the production of these two forms of energy.

In 1978, heat consumption in the USSR reached 12.5 billion GJ (three billion Gcal), and the fuel consumption for the production of heat exceeded 600 million tons of reference fuel, which is 1.5 times greater than was used for the production of electric power.

In the Soviet Union, unlike other countries, the development of the production of electric and thermal energy has been following the line of concentration and centralization for many decades. The fullest realization of the idea of the centralization of production was district heating, which is one of the main directions of rational utilization of fuel and energy resources.

At the present time, our country has about 1000 TETs [heat and electric power stations] with more than 3000 turbines of total electric capacity of over 70 million kW. The annual delivery of heat from TETs is approaching four billion GJ (one billion Gcal), which satisfies approximately 33% of the total heat consumption of the national economy.

Average specific consumption of reference fuel (net) for the delivery of electric energy from TETs for general use was 267 g reference fuel/(kWh) in 1978, which was 91 g less than the average specific consumption of fuel for condensation electric power stations (KES).

The development of heat supply from TETs is of great economic and social significance.

1. District heating systems produce a great saving in fuel. At the present time, annual savings in fuel from district heating amount to about 38 million tons of reference fuel; the average rate of annual decreases of specific consumption of fuel for the delivery of electric power from TETs is 5-6 g reference fuel/(kWh).

2. As a result of the development of district heating, the pollution of the environment decreases, the amounts of harmful substances injected into the atmosphere are reduced, thermal pollution of water reservoirs is lowered, and the sanitary condition of cities is improved.

3. Centralization of heat supply from TETs cuts down the need in the operating personnel of heat-generating facilities to 40%.

4. District heating yields a saving in the expenditures of the power industry of 5-12% in comparison with the separate method of heat production in boiler rooms and electric power at KES.

5. District heating, as a rule, ensures a high-quality and reliable heat supply to the consumers, as well as a reliable supply of electric power to cities and industrial centers.

Reliability improvement is one of the most important goals of heat supply. It must be solved in an integrated manner. During the designing stage, it is necessay to select heat sources correctly and soundly with consideration for their individual indices of reliability, location of the heat sources in the heat supply system, and redundancy possibilities.

Analysis of the operation of heat-supply systems under extreme conditions showed the presence of serious difficulties and defects in the organization of the operation and management of the systems of centralized heat supply, as well as in their designing and construction. Serious complaints against plants manufacturing the equipment were revealed.

Much work has to be done for evaluating the selection of heat supply systems and creation of reliable equipment for municipal peak sources of heat. The existing hot-water boilers have the following faults:

their heat-production capacity decreases when they work on mazut;

the life of the low-temperature part of the boilers is short due to intensive external corrosion;

their sensitivity to the quality of the network water is high (rapid scale formation if the water regime is disturbed);

auxiliary equipment does not work sufficiently reliably.

It is necessary to create a reliable peak hot water boiler for working on gas-mazut fuel, determine the type of the peak source of heat for TETs operating on solid fuel, and to design the structural part of buildings for peak boilers.

Many of these faults are due to the underestimation of the importance of heat supply and the importance of the timely provision of high-quality pipes, materials, and equipment for this branch of the power industry. In order to develop district heating, it is necessary to strengthen its repair and operation facilities and mechanize their work. At the present stage of the development of district heating, it is necessary to create a more flexible and reliable system for defect detection and elimination.

In the process of the analysis of causes of the deterioration of the quality of heat supply in a number of systems under extreme conditions, it was revealed that it is necessary to refine and reexamine some normative rules of the construction norms and regulations (SNiP), technical operation rules (PTE), norms for the designing of thermal electric power stations and thermal networks, and guidelines for water preparation and the chemical regime of water in thermal networks.

In August 1979, a meeting was held by the scientific and technical council of the USSR Minenergo [Ministry of Power and Electrification] at which changes to the norms of technological designing of thermal electric power stations and thermal networks were examined and approved. Proposals were prepared for introducing changes in other normative documents.

The insufficient reliability of heat supply is explained to a considerable degree by the absence or underproduction of many components of thermal networks, equipment, and materials. There is a need in high-quality pipes, corrugated compensators, locking and regulating equipment, heat insulation and hydraulic seals, corrosion-resistant coating for pipes, etc.

The production volume of automatic control and protection equipment, remote control equipment, devices for registering and monitoring the operation of heat supply systems, and automatic regulation of temperature for consumers is totally insufficient. Work on the wide introduction of the enamelling of pipes of the thermal networks is progressing slowly. Practical application of the results of studies in the area of heat supply conducted by the institutes of Minenergo and USSR Gosstroy is inadequate. Thus, it is necessary to do a very large volume of various jobs for raising the effectiveness of district heating.

Balanced development of the national economy is accompanied by a rapid growth and concentration of heat consumption.

Different conditions of the development of the industry and the housing and municipal sector of populated centers, as well as the special characteristics of the formation of a long-range fuel and energy balance in various regions of our country predetermine different routes for the development of heat supply.

In European parts of the USSR, according to numerous calculations of the organizations of the USSR Minenergo and the USSR Academy of Sciences, it is advantageous to build large TETs working on coal and gas even if a large-scale AES construction program is implemented.

Moreover, such TETs are more economical than separate heat and electric supply (AES + boiler rooms) practically in all regions of the European part of the country. It follows from this that the construction of AES is more effective until they replace the basic KES.

Only nuclear sources of heat can compete with TETs. Preparations for the use of nuclear fuel for heat supply are conducted at the present time in accordance with the directive of the 25th CPSU Congress.

Nevertheless, the insufficient experience, the attained state of development, and inadequate utilization of the potentialities of the power machine building facilities make it impossible to expect a widespread use of nuclear sources of heat until 1990. Therefore, in the next 10-15 years, there is no other sufficiently realistic alternative to the development of TETs on organic fuel in the European part of the country. There is no doubt that it is necessary to accelerate studies on a wider use of nuclear energy sources for district heating.

The lowering of the development rate of district heating, first of all, in the European part of the country proposed by some specialists who believe that this can substantially reduce the importation of organic fuel from the eastern regions would be a wrong solution which could result in extensive national economic losses. The unsoundness of this opinion can be seen from simple examples. Let us examine a TETs with a capacity of 100 MW which can deliver annually approximately four million GJ (one million Gcal) of heat and 0.5 billion kWh of electric energy, using 290,000 tons of reference fuel.

In order to obtain the same amount of heat from large boiler rooms and electric energy from KES, it will be necessary to use 400,000 tons of reference fuel a year, i.e., the importation fuel must be increased by 33%.

Even if we assume that it will be possible to produce the entire electric energy at an AES, then, it would seem that it is possible to lower the importation of fuel by approximately 20%. However, here we should examine the real structure of the operating electric power facilities.

In the next 10-12 years, it is impossible to count on the creation and sufficiently wide use of maneuverable AES adapted for operation in the semipeak part of the daily schedule of electrical loads. Until 1990, this part of the schedule will be covered primarily by TES [thermal electric power stations] and a certain part of GES. It has been proven by numerous calculations that heat and electric power stations are the best and most economical maneuverable facilities.

The operating KES of electric power systems of the European part of the country have a considerable number of small old and outdated turbines. On the average, these KES operate with a specific consumption of reference fuel of 390-400 g of reference fuel/(kWh). Some of them will be modernized according to plan and changed to a district-heating mode, which, by itself, will save up to 50,000 tons of fuel per each 100 MW. However, it is impossible for many reasons to change all uneconomical turbines to the district-heating mode. In many instances, it is more economical and socially correct to build new TETs at the locations where they are needed, and place old KES in reserve and dismantle them partially. Replacement of uneconomical KES with highly effective new TETs will save up to 100,000 tons of reference fuel a year per each 100 MW of the new installed TETs capacity.

Thus, as a result of the implementation of a rational technical policy, the development of district heating in combination with a program of AES construction will produce a substantial saving of organic fuel, and not its overexpenditure.

At the same time, many specialists believe that the rate of the development of district heating in the country is still not in line with the development rate of the national economy.

Scientists of the Siberian Energy Institute of the Siberian Branch of the USSR Academy of Sciences, in cooperation with the organizations of the USSR Minenergo, optimized the development of the fuel and energy complex of the entire country with consideration for various levels of the development of the heat supply facilities. Calculations showed that the scale of the development of district heating lags behind the optimal scale.

The USSR Gosplan should urgently examine the proposals prepared by the USSR Minenergo on the main directions and rational scale of the development of district heating in the country. These proposals take into consideration the difficulties with the transportation of large amounts of fuel from east to west, real possibilities of the expansion of the power machine building facilities, the developing structure of the growth of heat consumption in the national economy, and the requirements of environmental protection.

When determining the technical policy of the development of district heating in the European part, it is necessary to give serious attention to the utilization of the operating KES and those under construction for heat supply to nearby comsumers.

At the present time, the USSR's KES have more than 100 turbines with a unit capacity of 200 MW and less which have been changed to the district heating mode. There are proposals and plans to use K-300-240 turbines yielding 500-837 GJ/h(120-200 Gcal/h) of heat. On the average, each condensation power unit used for district heating saves 70,000 tons of reference fuel a year, reducing the expenditures on the power industry by approximately 1.5 million rubles a year.

The opinion of some specialists that the changeover of condensation power units to the district heating mode lowers sharply their maneuvering possibilities is hardly valid. If the steam bleeding from the turbine is removed properly, its maneuvering properties remain practically the same, and the loading of the boiler of the power unit levels out as a result of the modes of direct supply of fresh steam to the district-heating heaters (during the hours when the turbine is stopped).

In recent years, attention is given to the use of AES for supplying heat to nearby cities and hothouse combines. Plans have been developed, but, on the whole, work in this area is just beginning.

Plans for the development of district heating must be coordinated with plans for the construction of large boiler houses. In the opinion of the authors, boiler houses with a capacity of over 210 GJ/h (50 Gcal/h) combined optimally with TETs are sufficiently economical and quite modern (promising) sources of centralized heat supply.

It is necessary to expand scientific research and design studies on the creation of new highly reliable hot water and steam boilers of high capacities.

It is expedient to bring the unit capacity of hot water boilers to 1050 GJ/h (250 Gcal/h), and the productivity of steam boilers with a pressure of about 4.0 MPa to 160 t/h, increasing their reliability.

As experience shows, large boiler houses can operate with a specific consumption of 40.4-40.7 kg of reference fuel/GJ (169-170 kg of reference fuel/Gcal), i.e., consuming 10-12 kg/GJ less fuel than heat sources of decentralized heat-supply systems.

The development of centralized heat supply is accompanied by an increase in the length of thermal networks and expenditures in them. At the present time, the USSR has 180,000 km of thermal networks including about 20,000 km of main systems.

In most cases, heating mains are laid under the surface of the ground in impenetrable channels of various designs. In recent years, a channelless method of laying started being used widely, when the heat and water inculation layer on the pipelines is made sufficiently strong to endure the pressure of the soil, vehicles, ground water, etc. One of the methods is to lay pipelines in autoclaved reinforced foam concrete. This method has been used quite successfully in Leningrad for about 30 years.

The first experiment in laying with the use of heat and water insulating structures based on a bituminous binding material (bitumoperlite, bitumovermiculite, bituminous porous clay filler) yeilded satisfactory results only in good soil conditions. Therefore, extensive scientific studies are now in progress in order to improve this type of insulation.

Polymer concrete is a promising type of insulation for channelless laying. But it is still necessary to do a large complex of research jobs in order to find polymeric compositions with the required complex properties.

Most of the damage to the pipelines of thermal networks is caused by external corrosion. Intensive corrosion of pipes is responsible for more than 80% of all damages in thermal networks.

Measures are taken to protect pipes against corrosion by means of enameling, aluminizing, and painting with special paints. In cities, protection of pipes against electric corrosion (drainage, cathode, protective) is being introduced quite widely.

In the last 10-15 yeats, organizations of the USSR Minenergo and USSR Gosstroy have done much in developing reliable designs of thermal networks. A unified series of sectional impervious reinforced-concrete channels has been developed and introduced, heat insulating structures and structural components of supports have been standardized, and unified normative materials have been developed for calculating the strength, thermal and hydraulic properties, as well as norms of technological designing, SNiP, and others.

In order to ensure the delivery of heat from centralized heat supply sources, 100,000-110,000 km of thermal networks will have to be built in the near future.

At the present time, the rate of the introduction of thermal networks is lagging very much behind the introduction of thermal capacities. As a result of this, much harm is done to the national economy.

The obtaining of high-quality energy-producing fuel for city TETs by reprocessing and dressing of coal and combustible shale is an important national economic problem. One of the important methods of dressing is purification by the power-technology method with high-speed pyrolysis and a combined heat carrier. The process of thermal processing of coal in vortex chambers also appears to be promising. It is necessary to speed up the creation of large experimental industrial units of the above types.

In connection with the raising of the requirements for clean air and special characteristics of city planning, as well as changes in the fuel structure of the power industry in the direction of increasing the share of solid fuel and, in the near future, of nuclear fuel, many high-capacity TETs will be located at considerable distances from the areas of heat consumption, often far beyond the city limits, which will require the construction of long heat-supply pipelines. This requires additional studies, but should not be viewed as an obstacle for the development of district heating systems.

When a TETs is located 15-20 km beyond the city limits, specific capital investments in long-distance heat-supply lines are approximately 2400 rubles/GJ/h (10,000 rubles per 1 Gcal/h), and the annual saving in fuel due to combined production alone amounts to 48 tons of conventional fuel per 1 GJ/h (200 tons of conventional fuel per 1 Gcal/h). Therefore, the initial expenses for the construction of long-distance heat pipelines constitute 40 rubles/ton of the annual savings in fuel, which is 3-4 times lower than the specific initial expenses for the creation of a fuel base and the corresponding fuel-transportation communication systems.

On the whole, the use of pipes for centralized heat supply will continue to grow. The USSR Gosplan, USSR Gosstroy, and USSR Gossnab must help in satisfying the needs of the power industry in pipes.

In principle, nobody objects against the development of district heating in the eastern regions of the country. The orientation of the national economy of these regions toward the development of such heat-consuming industries as chemical and petrochemical, pulp and paper, and wood chemistry, in combination with the severe climatic conditions predetermine accelerated growths of heat consumption and its considerable concentration. Moreover, if we consider the presence of sufficient quantities of a relatively cheap coal, shortage of manpower reserves, great need in electric power, and the necessity of cleaning the air of Siberian cities which is considerably polluted by small boiler houses, then it becomes obvious that it is expedient to develop district heating systems on the basis of TETs operating on solid fuel beginning with thermal loads of 1680-2930 GJ/h (400-700 Gcal/h).

Heat supply to the consumers of the extreme north is an extremely complex problem. This complexity is due to the selective development of natural resources, focal distribution of industries and housing, severe climate, low concentrations of thermal loads, and high costs of the transportation of fuel, materials, etc. Most probably, it will be promising to introduce small nuclear plants there in combination with the use of traditional methods of heat and electric power supply within reasonable limits.

The unquestionable advantages of district heating are now recognized all over the world. District heating is being introduced widely in socialist and capitalist countries. Scientists of various countries are working successfully on the improvement of heat supply systems and creation of new and more economical equipment.

District heating is one of the main sources of increasing the effectiveness of this industry. The technical policy directed toward maximal development of district heating must continue to be the leading trend for the next few decades.

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CONDENSATION ELECTRIC POWER STATIONS FOR CENTRAL HEATING

Moscow TEPLOENERGETIKA in Russian No 2, Feb 80 pp 6-10

[Article by Yu. A. Aberbakh, V. P. Brazovskiy, M. I. Gitman, G. I. Goncharov, L. I. Levin, T. A. Maslova, S. V. Privezentseva, and S. Z. Pruss, engineers]

[Text] The development of the power industry in the European part of the country in the next period is characterized by the construction, chiefly, of atomic electric power stations and simultaneous increase in the variable part of the schedule of electrical loads. This leads to limitations in the construction scales of new TETs operating in the basic part of the schedule and requires wide involvement of KES [condensation electric power stations] power units operating on organic fuel for covering the variable part of the schedule of electrical loads [1, 2].

These KES, particularly those with power units of 160, 200, and 300 MW can be made more economical, if there are consumers of heat near the stations, by reconstructing their turbine units for combined production of heat and electric energy. However, such reconstruction is connected with some loss in maneuverable power. Therefore, studies were done for the optimization of the conditions when such power units are changed to the district-heating mode of operation. Expedient forms of using reconstructed power units of KES for district heating were determined.

The reconstruction schemes of power units used in this study were developed by the Kharkov Branch of the TsKB [Central Design Office] and some of them were used at the operating KES [3].

The effectiveness of reconstruction was determined depending on the type of the turbines, initial modes of their operation before reconstruction, climatic conditions, type and cost of fuel, thermal load, calculated values of alpha $_{\text{т}}$, $\varphi_{\text{г.в}}$ and Q $_{\text{отб}}$, temperature chart of the network, and the distance at which heat has to be transported.

The natural decrease in the thermal loads during the hours of minimal electrical loads was not taken into consideration in the calculations due to the probability of a considerable transportation delay when heat is to be transported at long distances.

In establishing the initial operation modes of power units before reconstruction, it was taken into consideration that in most regions of the European part of the country, due to the necessity of lowering considerably the generating capacities during the hours of minimal electrical loads, units of 150-300 MW are partially unloaded and partially stopped at night and days of rest. It is permissible to unload power units by 30% if they work on solid fuel, and by 50% if they work on gas and mazut. The stopping of power units is practiced more frequently during days of rest chiefly at gas-mazut KES and, essentially, is limited to K-150 and K-200 turbines [1, 4].

In determining the operation modes of power units after reconstruction in the European part of the country, rated power was examined for each variant in three zones of the schedule: minimum, semipeak part of the schedule (working day), and peak hours. The rated power in the minimum zone in the case of unloading for each value of steam bleeding was determined as the power at the minimal passage of team into the condenser. The minimum calculated value of bleeding was taken to be such at which the consumption of live steam for the turbine is equal to the minimum permissible value for the boiler. In the case of the stopping during the minimum hours before reconstruction, analogous stopping after reconstruction was taken into consideration, since giving it up would lead to the replacement of the semipeak mode with the basic mode for a part of the unit power and this, in turn, would require a considerable increase in the introduction of semipeak capacities in the power system, which is practically unrealistic and, according to calculations, is economically disadvantageous.

Due to structural difficulties connected with the presence of industrial overheating, the variants of the stopping of reconstructed turbines during the minimum hours with transmission of the bleeding loads to power-plant boilers through specially installed ROU [pressure-reducing and cooling units] and boilers were not examined and it was considered that the stopping is possible only for the entire boiler-turbine block.

In the semipeak part of the schedule, it was assumed that reconstructed power units will be working at the rated value of steam bleeding and nominal flow rate of live steam.

We examined the economic expediency of partial "restoration" (boosting) of the power of power units during peak hours by lowering the bleeding load and its transmission to specially installed hot water boilers. Calculations have shown that this is not justified economically in comparison with alternative sources of peak power (GTU [gas turbine engines] with the use of the heat of outgoing loads).

In Siberian regions, where it is not required to unload power units during minimum hours, reconstructed power units operate around the clock with nominal consumption of live steam and rated steam bleeding.

In order to compensate the changes in the power of reconstructed power units over the zones of the 24-hour schedule, the following alternative sources of power in the OES [Integrated Power System] were considered:

during minimum hours (basic part of the schedule) -- AES (in the eastern regions, KES operating on organic fuel);

in the semipeak zone -- semipeak KES on solid fuel (with the possibility of using more economical sources of semipeak power -- semipeak steam-gas KES, semipeak TETs, GAES [pumped-storage electric power stations] and others, the effectiveness of the reconstruction of KES blocks increases, which creates additional reserve in the calculations).

The annual production of electric energy by a reconstructed power unit was determined from the condition that the useful delivery of electric power after reconstruction plus (minus) the delivery of electric power from alternative sources would be equal to the useful delivery before reconstruction.

Calculated values of $Q_{отб}$ [bleeding] changed from the above-mentioned minimum value to the maximum value determined by the method of reconstruction.

The calculated values of the consumer load changed from 1250-1670 to 6270-8370 GJ/h.

The changes in the share of hot water supply $\varphi_{г.в}$[hot water supply] with two-pipe transportation of heat within the limits of 0.10 to 0.20, according to preliminary calculations, practically do not affect the results, therefore, a constant value of $\varphi_{г.в}$ 15% is taken hereafter.

The values of alpha$_T$ in the case of a two-pipe transportation method of heat varied within the limits of 0.3-0.65.

Two calculated temperature schedules were examined for K-200 turbines: normal of 150/56 degrees C and a higher schedule. Calculations have showed that the use of the higher temperature schedule worsens the effectiveness of reconstruction (within the limits of heat transportation distance which is equally economical with a separate scheme), since it is connected with great energy losses.

The difference of this conclusion from the conclusions obtained earlier in the calculations on the transportation of heat from TETs is explained by greater energy losses when reconstructed turbines are put on higher temperature schedule in comparison with district-heating turbines and by an increase in the cost of these losses due to higher costs of fuel.

Due to the similarity of the maneuverability requirements and relatively small changes in the climatic conditions in the European part of the country, calculations for the reconstruction of units were done in application to one OES of the South.

The closing expenses on fuel in the European part were taken to be 35 rubles/ton of reference fuel for coal and 43 rubles/ton of reference fuel for gas and mazut; in the OES of Siberia, in the regions of cheap fuel (Kansk-Achinsk coal)seven rubles/ton of reference fuel and in regions of expensive fuel (other regions) 17 rubles/ton of reference fuel. The closing expenses on the electric power for atomic stations are taken to be 14 rubles/(MW·h) at $T_a = 6500$ h/year. Heat transportation distances varied within the limits of equal economy with separate schemes.

In connection with the fact that KES are located outside of municipal housing construction areas and their areas are limited, the construction of peak hot-water boilers in all instances was planned in the regions of heat consumption, and heat transportation was taken into consideration only through main pipelines.

Expenditures on a separate scheme were determined in application to the construction of new boiler rooms. It was considered that, in the presence of operating rayon boiler rooms, they can be used both in the separate scheme and as a peak facility during reconstruction.

For the separate scheme, just as for peak hot water boiler rooms in the reconstruction variant, it was considered that the same type of fuel is used as at a reconstructed KES.

The main effect of reconstruction on the balance of capacities in a power system is the loss of power during the daytime and peak hours. The effect of the operation modes of a unit during the hours of minimal electrical loads in the European part of the country consists in the fact that, during unloading, the power of the power units in this zone of the schedule changes after reconstruction, and, depending on $Q_{OT\delta}$, this can somewhat reduce or increase the extent of the unloading.

As the calculated value of the bleeding increases, the maneuverability of the power unit deteriorates, since its power decreases during the maximum hours, and increases during the unloading during the minimum hours. However, the share of combined output increases simultaneously. When the power unit is stopped during the minimum hours, the share of the combined output will be lower in all instances.

Table 1 illustrates this by the data for a K-200 power unit which had a power of 210 MW before reconstruction, and during the minimum hours when it was unloaded -- 147 MW for coal KES and 103 MW for gas-mazut KES.

Calculations have shown that the variants for K-200 turbines in the case of reconstruction are approximately equally economical and optimal in the entire range of consumer loads at the value of $\alpha_T = 0.3 \div 0.4$.

The main reason why the power unit is economical at a low value of α_T is a relatively higher share of the combined output which, on the whole,

Table 1

Limit Values $Q_{OT\sigma}$ [bleeding] GJ/h	Type of Fuel	Power, MW		Percentage of Combined Production, %	
		Maximum	Minimum at Unloading	At unloading during minimum hours	When stopped during minimum hours
Maximum 630	Coal, gas, and mazut	188	147	39	32
Minimum 495	Coal	197	134	31	24
Minimum 270	Gas, mazut	204	103	17	13

Note. Indexes were calculated at a normal temperature schedule and $\alpha_t = 0.4$.

is considerably smaller for reconstructed KES than TETs with district-heating turbines, which is explained by a greater assiciated condensation power and one-step removal of heat to the network heaters. Calculations have also shown that, for these turbines, changes of $Q_{OT\sigma}$ in the entire possible range practically do not affect the economic nature of reconstruction at a constant value of α_T. Therefore, in order to reduce the number of reconstructed turbines, the calculated value of the bleeding should be taken close to the maximum value.

Table 2

Loads	K-200 (coal, gas and mazut	K-300	
		Coal	Gas and mazut
Average bleeding load, GJ/h	565	590	460-500
Average consumer load per one power unit, GJ/h	1700	1300-1420	1050-1130
Consumer load range (GJ/h) for the following numbers of reconstructed power units:			
2	up to 3350	Up to 3550	Up to 2500
3	3350-5000	3550-4800	2500-3550
4	5000-6700	4800-6100	3550-4800
5	6700-8400	6100-7100	4800-6050
6	-	7100-8400	6050-7100

For K-300 turbines, due to a higher pressure in the bleeding, a higher temperature schedule is used. The optimal value of α_T will be 0.4-0.5. For the same reason, the maximum bleeding of a K-300 turbine which is equal to 965 GJ/h is not optimal, and changing from a smaller number of reconstructed turbines with large bleeding values to a larger number of turbines with a lower bleeding value increases the effectiveness of reconstruction. Therefore, the optimal bleeding value for reconstructed coal units K-300 can be taken to be close to the minimum permissible value for the boiler -- 545 GJ/h. The calculated bleeding value for gas-mazut units can be still lower. However, in the case of the lowest bleeding (251 GJ/h), the share of the combined output is very small, the number of reconstructed turbines per a unit of consumer load increases sharply, and the additional gain in the power capacities is not great. In this connection, as well as taking into consideration the undesirability of reconstructing an extremely large number of turbines, the calculated bleeding of gas-mazut units K-300 should be taken to be close to the calculated bleeding of units operating on coal. The load of 545 GJ/h can be considered as the upper limit.

Optimal thermal capacities and loads corresponding to average values of α_T = 0.35 for K-200 units and 0.45 for K-300 are shown in Table 2.

Under the above conditions, the effectiveness of reconstruction will be considerably higher than that achieved at the present time, when practically all of the thermal load is covered from the bleeding of turbines ($\alpha_T = 1$), which leads to the reconstruction of excessive numbers of turbines and great power losses. However, in this case, due to low costs and the short duration of reconstruction, it is expedient to start district heating by reconstructing KES with subsequent construction of peak-load boiler rooms as thermal loads grow.

The main technical and economic indices of power units after reconstruction are compared with analogous data before reconstruction in Table 3. Two values are given for specific fuel consumption after reconstruction: for the power unit proper and with consideration for leveling in the system, i.e., with consideration of fuel consumption by alternative sources (semipeak units). Changes in the consumption of nuclear fuel at AES were not considered, therefore, the index does not fully characterize the changes in the consumption of all types of fuel in the power system.

At gas-mazut KES which are unloaded during the minimum hours total expenses of organic fuel practically do not decrease as a result of reconstruction, since the entire saving obtained through combined production is absorbed by the overexpenditure of fuel at semipeak units which must be introduced in order to compensate the decrease in the extent of unloading. However, this will produce a saving of nuclear fuel due to a decrease in the AES power.

In accordance with the above data, general indices of normalized expenditures on the reconstruction of KES, delivery of heat from them and the leveling in the power system are differentiated for various operation modes in the minimum hours. During stoppage, this expenditures are greater than during unloading by 5-20%. Further interpretation of the obtained data consists in the evaluation of the share of units used in each of the above-mentioned modes and determination of medium weight indexes of normalized expenditures during their reconstruction. For K-200 turbines, the following combinations of operating modes of power units before reconstruction are examined:

unloading during the minimum hours -- 70%, stopping -- 30%;

unloading during the minimun hours -- 50%, stopping -- 50%.

Table 3

Indexes	K-200				K-300			
	Coal		Gas, Mazut		Coal		Gas, mazut	
	Unloading	Stopping	Unloading	Stopping	Unloading	Stopping	Unloading	Stopping
Power losses due to reconstruction, %	10	10	10	10	8	8	7	7
Output on heat consumption, %	37	30	37	30	22	18	18	13
Share of heat delivery from bleeding	0.70	0.45	0.70	0.45	0.85	0.55	0.85	0.55
Specific output on heat consumption kWh/GJ	138	138	138	138	134	134	134	134
Specific fuel consumption before resonstruction, g/(kWh)	343	347	341	336	336	336	335	326
after reconstruction, g/(kWh)	259	276	247	246	290	302	265	270
with consideration of leveling in the power system, g/(kWh)	269	286	272	280	290	306	280	275
Total consumption of organic fuel for the production of electric energy and heat before reconstruction (separate scheme) calculated for one power unit, 1000 ton reference fuel	633	568	592	548	749	693	690	654
Total comsunption of organic fuel after reconstruction with consideration of leveling, 1000 ton reference fuel	540	506	585	487	612	642	665	565
Fuel economy due to reconstruction, 1000 ton reference fuel	93	62	7	61	137	51	25	89
Same, %	15	11	1	11	18	8	4	14

For K-300 power units, only the first of the above-mentioned combinations is examined.

For K-200 turbines, the relative effectiveness of the reconstruction of coal and gas-mazut KES is practically identical. This is explained by the fact that reconstruction of gas-mazut units ensures savings of a more expensive fuel but leads to greater losses of maneuverability during unloading in the minimum hours. The maximum distance of heat transportation (equally economical with the separate scheme) changes from 17-18 km with a consumer load of 2090 GJ/h to 22-25 km at 6280 GJ/h. At a load of 4190 GJ/h and heat transportation distance of 10 km, the specific economic effect of the reconstruction is 836 rubles of normalized expenditures per 1 GJ/h, or 1.4 million rubles per one power unit.

For reconstructed K-300 power units, unlike K-200, the maximum transportation distance of heat for coal and gas-mazut KES differs and depends to a greater degree on the consumer load. For example, at $Q_{consumer}$ = 2090 GJ/h, this distance for coal units constitutes 23 km, and at 6280 GJ/h it is 38 km. For gas-mazut units, these distances are respectively 30 and 50 km. The specific economy of the normalized expenditures in comparison with the separate scheme for a distance of heat transportation of 10 km is 0.95-1.4 thousand rubles per 1 GJ/h for coal units and 1.7-1.9 thousand rubles for gas-mazut units. A relatively greater effectiveness of the reconstruction of gas-mazut units in comparison with coal units is explained, chiefly, by a smaller calculated load of the bleeding per one power unit, which ensures lower power losses and greater costs of the saved fuel.

Calculated for an indentical consumer load, the reconstruction of K-300 units yields a considerably greater effect than the reconstruction of K-200 units, particularly for large loads and long distances. This is explained by the fact that, due to a higher rated value of α_T, the yield of heat from the bleeding of K-300 turbines referred to a unit of consumer load is approximately 20% greater than that of K-200, while the expenses on the transportation of heat are lower. Therefore, if there are turbines of both types at a KES, it is expedient to use K-300 power units for heat supply first of all. Additional possibilities for this are created due to a considerable increase in the economically expedient distance of heat transportation.

The distances mentioned here were obtained in the assumption of a considerable increase in the cost of fuel and stable prices on metal. If we assume for the verification of these conclusions that the cost of heat transportation increased by a factor of 1.5, which corresponds to an increase in the cost of pipes not less than by a factor of 2, then the maximum distance of heat transportation for which it is expedient to reconstruct power units in the European part of the country will be approximately 12-17 km for K-200 turbines and 15-30 km for K-300 turbines.

In the OES of Siberia, where reconstruction of K-200 power units operating on coal was examined in connection with the existing KES equipment, due to a lower cost of fuel, calculations for a higher temperature schedule have also been performed. Calculations showed that it is not expedient to use a higher schedule and that the reconstruction of power units is considerably less economical than in the European part of the country. Thus, reconstruction of power units in a region of cheap fuel is practical only when the KES is in the immediate vicinity of heat consumers ($L \leq 2$ km), and in the region of expensive fuel it is expedient if the heat transportation distance is not over 8 km.

In 1978, requests were received for designing the reconstruction of KES power units for a total thermal load of approximately 63,000 GJ/h and a distance to heat consumers, chiefly, within the limits of 10 km. With the obtained maximum values of the heat transportation distance, the value of the thermal load on the KES can be estimated at least at 168,000-209,000 GJ/h, to which corresponds a thermal capacity of reconstructed units of 67,000-84,000 GJ/h. In this case, only 25% of the entire available thermal capacity of the power units and about 35% of their optimal thermal capacity will be used. The use of such thermal capacity corresponds to the introduction of more than 100 new turbines of the T-100-type at a TETs, but requires immeasurably smaller capital investments.

The overall effect of reconstruction in this case will exceed 100 million rubles of calculated expenses, and the annual saving in organic fuel wil be about 8 million tons of reference fuel.

The obtained values of the effectiveness of reconstruction were determined on the basis of the necessity of constructing semipeak KES in order to compensate losses of power during reconstruction and the decrease in the extent of the unloading of gas-mazut units during the minimum hours.

In reality, it is possible to avoid the introduction of new semipeak capacities if, in order to compensate losses of power without lowering bleeding loads, provisions are made during designing for the possibility of shutting off the PVD [high-pressure superheater] and increasing the passage of steam into the condenser, and, in order to lower the power of gas-mazut units during the minimum hours to a value permitted before the reconstruction, additional hot-water boilers are installed into which part of the bleeding loads is transferred during the minimum hours. The increase in the productivity of hot-water boiler rooms for K-200 units will amount to 25% and for K-300 to about 10% of their necessary productivity at rated values of α_T and $Q_{OT\delta}$. With consideration for the discreteness of the type sizes of the equipment, these values will be still smaller.

Additional expenditures connected with the measures enumerated above will be considerably lower than would be required for the construction of semi-peak KES.

Conclusions

1. Under present conditions, reconstruction of KES power units of 150-300 MW for the purposes of heat supply is practical and yields a great economic and social effect, expanding the area of the application of centralized heat supply and ensuring a considerable saving in organic fuel without any substantial loss of the maneuverable power in the power system.

2. Because of the condition for ensuring maneuverability, the operation modes of reconstructed units must correspond as much as possible to their operation modes before the reconstruction. For example, provisions have to be made for their stopping during the minimum hours of electrical loads in the same volume as before their reconstruction.

3. The optimal value of the coefficient of district heating with a two-pipe transportation system of heat is 0.3-0.4 for reconstructed K-200 and K-300 turbines.

4. For consumer loads of up to 6280 GJ/h, the number of reconstructed units at a KES will, as a rule, be not more than three or four, which in the majority of cases will not exceed one half of all installed units.

5. Specific consumption of fuel by reconstructed units decreases by 20-25%, and, with consideration for the leveling of the output of electric power in the power system, it decreases by 10-20%.

6. The maximum distance of a two-pipe transportation system of heat equally economical with the use of a separate scheme in a range of thermal loads of 2090-6280 GJ/h is:

in the European part of the country for K-200 turbines -- 18-25 km, for K-300 turbines operating on coal -- 23-38 km, and those operating on gas and mazut -- 30-50 km;

in Siberia, in the regions of cheap fuel (Kansk-Achinsk basin) -- up to 2 km, and in other regions -- up to 8 km.

7. Further improvement of the reconstruction schemes of KES power units for heat supply must be conducted in the following directions:

lowering of the associated condensation power for reducing specific fuel consumption and ensuring a more extensive unloading during the minimum hours;

creation of the possibility of stopping the turbines during the minimum hours while maintaining the operation of power-plant boilers and switching thermal loads of consumers to them;

creation of the possibility of increasing capacities of reconstructed units during peak hours without lowering the bleeding loads.

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FUEL ECONOMY IN CENTRAL HEATING

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[Article by D. T. Arshakyan, Candidate of Technical Sciences, Armenian Scientific Research Institute of Power Engineering]

[Text] Almost in all developed countries of the world, the consumption of power resources for the purposes of heat supply substantially exceeds the consumption of energy resources for electric power supply. Therefore, the problems of the improvement of heat supply and its fuel resources are becoming exceptionally urgent.

About one third of the consumed energy resources are used for the purposes of heat supply. A substantial share in these energy resources belongs to high-quality types of fuel, such as natural gas and petroleum products which are very valuable for other sectors of the national economy.

In recent years, the above circumstances have strengthened the tendency toward rapid development of heat supply systems on the basis of nuclear energy almost all over the world [1-3].

The development of power engineering in the USSR at the present stage is characterized by accelerated introduction of new capacities primarily through construction of large heat and atomic electric power stations. In the European part of the USSR, it will develop, chiefly, through construction of large atomic electric power stations equipped with high-capacity power units VVER-1000, VK-500, RBMK-1000, and others; in the eastern regions of the country, chiefly, through construction of large GRES equipped with high-capacity power units working on solid organic fuel (primarily brown coal).

At the present time, the problems of optimal development of power sources on organic fuel are becoming particularly urgent. This refers particularly to the development of district heating on organic fuel which plays an exceptionally important role in the economy of energy resources, increase of labor productivity, as well as in protection of the environment against harmful ejection of combustion products.

Under the present conditions, it becomes necessary to examine special characteristics of the development of district heating using organic fuel in high-capacity developing power systems. It is necessary to examine the degree of economy of the development of district heating in conjunction with the construction of large AKES [atomic condensation electric power stations] in the European part of the USSR and the construction of high-capacity GRES using solid organic fuel in the eastern regions.

Analysis of the results of studies on the determination of the degree of economy of district heating using organic fuel in large developing power systems is given below.

The economic criterion in the optimization of the development of district heating in power systems is the economy of proportionate adjusted expenses per unit of electric power of a TETs -- normal expenses $з_{эк}$ and with consideration of adjustment $з_{эк}^{пр}$. It is evident that the optimal variant will be the one satisfying the conditions $з_{эк} \longrightarrow$ max, $з_{эк}^{пр} \longrightarrow$ max [4].

Expenses in a combined and a separate schemes of power supply must be calculated with consideration of the fact that they occur at different times over the years of calculated period, which is done by their adjustment by the compound interest formula to some one year [4-6].

Capital investments and annual operational expenses in the year i of the calculated period can be determined on the basis of the existing materials on the norms, instructions, and methods and functional relations developed on their basis [4, 6].

The most difficult part of such studies is the determination of the actual fuel consumption at a TETs which is in a complex functional dependence on the parameters and operation modes of the installed equipment in a given heat supply system, climatic conditions, etc. A mathematical model has been developed for determining fuel consumption at TETs equipped with district-heating turbines of the types R, PT, and T with consideration for all of the above-mentioned variable factors [7-9].

The actual fuel consumption at a TETs determined by the developed model is 6-8% lower than the fuel consumption determined on the basis of average normative data [8, 9]. This may play a decisive role in the determination of the expediency of the development of district heating for a given load and in given conditions.

Studies on the optimization of the development of district heating using organic fuel were done on the basis of district-heating turbines T-100-130, T-175-130, and T-250-240 in different power systems and under different climatic conditions: from Yerevan (climatological coefficient K_k = 2850 h) to Yakutsk (K_k = 3980 h) for periods n = 5, 10, 15 years when the full thermal load reaches the calculated value [4, 7].

Comparison is made of the degree of economy of district heating when TETS operate on solid organic fuel, and when peak-load boiler rooms and replaced rayon boiler rooms operate on gas and mazut. The degree of economy of district heating when a TETs works on gas and mazut is also examined. Analysis is made of the operation of developing power systems based on high-capacity condensation electric power stations using organic fuel (GRES-4800 with power units K-800-240 on solid fuel) and nuclear fuel (AKES-4000 with VVER-1000 units). The cost of fuel $з_Т$ is taken to be 30, 40, 50 rubles/ton reference fuel.

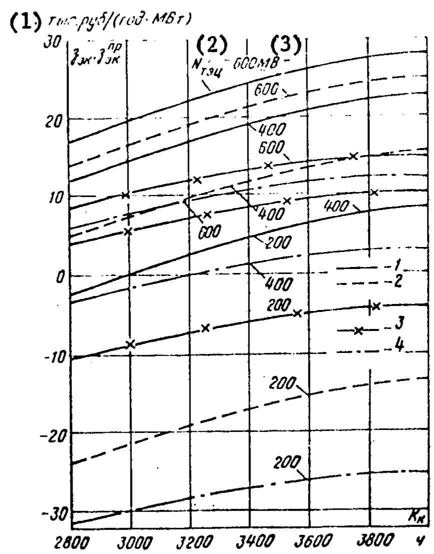

Figure 1. Dependence of the Degree of Economy of Proportionate Adjusted Expenses on the Climatological Coefficient $з_{эк}=f(K_к)$ and $З_{эк}=\varphi(K_к)$ for the T-100-130 Turbine with the Adjustment Period n = 15 Years (TETs Using Solid Fuel, Replaced GRES-4800 with Power Units K-800-240).

1 -- $з_{эк}$ at $з_Т$ = 50 rubles/ton reference fuel;

2 -- $з_{эк}^{пр}$ at $з_Т$ = 50 rubles/ton reference fuel;

3 -- $з_{эк}$ at $з_Т$ = 30 rubles/ton reference fuel;

4 -- $з_{эк}^{пр}$ at $з_Т$ = 30 rubles/ton reference fuel.

Key: 1. Thousand rubles/(year·MW)
2. TETS
3. MW

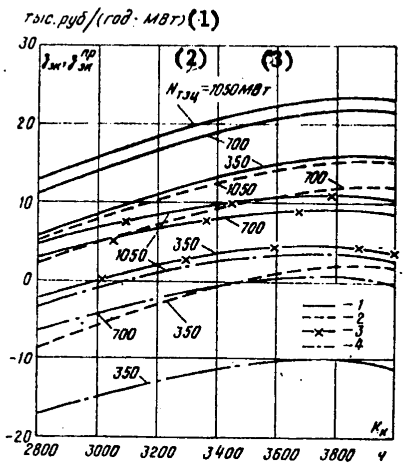

Figure 2. Dependence of $з_{эк} = f(K_k)$ and $з^{пр}_{эк} = \varphi(K_к)$ for the T-175-130 Turbine at n = 15 years (TETs on Solid Fuel, Replaced GRES-4800 with Power Units K-800-240). See Figure 1 for designations 1-4.
Key: 1. Thousand rubles/(year·MW)
2. TETs
3. MW

In examining the degree of economy of district heating, the following TETs capacities are taken: for the T-100-130 turbine -- from 200 to 600 MW; for the T-175-130 turbine -- from 350 to 1050 MW; for the T-250-240 turbine -- from 500 to 1500 MW.

Figures 1-3 show the dependence of the degree of economy of proportionate adjusted expenses $з_{эк}$ and $з^{пр}_{эк}$ on the climatological coefficient K_k for turbines T-100-130, T-175-130, and T-250-240 when TETs uses solid organic fuel and the length of the period when a full thermal load is reached n=15 years [4, 7].

The curves in Figures 1-3 show that the degree of economy of district heating depends considerably on the correlation of the initial steam parameters at the TETs and replaced GRES, unit power of the turbines, and the total power of TETs and GRES, thermal load, its density and growth dynamics, type and cost of fuel, as well as on climatic factors.

For example, if the TETs is equipped with powerful turbines T-175-130 and T-250-240, district heating is absolutely economical for the cost of fuel $з_т$ = 40 rubles/ton reference fuel and higher for any of the above-mentioned TETs capacities, and for all ranges of changes in K_k, i.e., for al regions of the USSR. When the cost of fuel is 30 rubles/ton reference fuel,

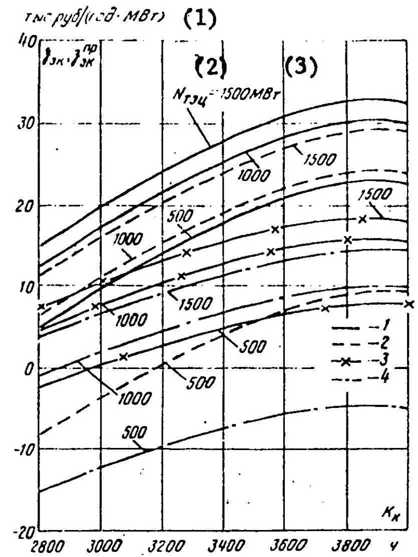

Figure 3. Dependence of $з_{эк} = f(K_k)$ and $з_{эк}^{пр} = \varphi(K_к)$ for the T-250-240 Turbine at n = 15 Years (TETS on Solid Fuel, Replaced GRES-4800 with Units K-800-240). See Figure 1 for designations of 1-4.
Key: 1. Thousand rubles/(year·MW)
2. TETs
3. MW

the use of T-175-130 and T-250-240 turbines is economical for all regions of the USSR if the TETs capacity is high (700 MW and higher for TETs with turbines T-175-130 and 750 MW and higher for TETs with turbines T-250-240); TETs with T-100-130 turbines is found to be economical only for high capacities of TETs, high cost of fuel, and in more severe climatic conditions. The use of T-100-130 turbines in the southern regions is not economical even if the cost of fuel is high (up to 50 rubles/ton reference fuel). The degree of economy of district heating on organic fuel increases substantially when TETs uses gas-mazut fuel. Studies showed that in such cases district heating on the basis of TETs equipped with turbines T-100-130, T-175-130, and T-250-240 is absolutely economical for all regions of the USSR, for any of the above-mentioned TETs capacities and cost of fuel.

The above conclusions regarding a relative economy of district heating on the basis of the above-mentioned turbines were made without consideration of the effect of the dynamics of growth of thermal loads, i.e., without consideration of adjustment. The analysis of the results of this study indicates that the growth dynamics of thermal loads has a substantial effect on the degree of economy of district heating of cities, particularly if TETS uses solid fuel and the period of reaching full thermal load is long (n=15 years). For example, district heating on the basis of a powerful turbine T-250-240 is economical for all regions of the USSR if TETs capacities are 1000 MW or higher and the cost of fuel $з_T$ = 30 rubles/tone reference fuel. It is economical to use T-175-130 turbines for all regions of the USSR if TETs capacities are high (700 MW and higher) and cost of fuel $з_T$ = 40 rubles/tons reference fuel and higher. If the cost of fuel is relatively low, TETs with capacities of up to 700 MW are not economical for all regions of the USSR.

The effect of the growth dynamics of thermal loads on the degree of economy of district heating is particularly substantial when district heating turbines have a relatively low unit power. For example, at n = 15 years, district heating on the basis of TETs equipped with T-100-130 turbines is not economical for all regions of the USSR for TETs capacities of up to 400 MW and fuel costs of up to 40 rubles/ton reference fuel; a 200 MW TETs is not economical even in the case of high costs of fuel ($з_T$ = 50 rubles/ton reference fuel).

If the period of the achievement of full thermal load is relatively short (n = 5 years), the effect of the growth dynamics of thermal loads on the degree of economy of district heating is not very pronounced. For example, a TETs-500 based on a T-250-240 turbine becomes economical for all regions of the USSR if the cost of fuel $з_T$ = 50 rubles/ton reference fuel, in most regions of the USSR at $з_T$ = 40 rubles/ton reference fuel, and in severe climatic conditions (K_k = 3700 h and higher) at $з_T$ = 30 rubles/ton reference fuel.

Studies have shown that the effect of growth dynamics of thermal loads on the degree of economy of district heating is insignificant if a TETs works on the gas-mazut fuel. For example, district heating based on TETs equipped with turbines T-100-130, T-175-130, and T-250-240 is economical for all regions of the USSR for any of the above-mentioned capacities of TETs and cost of fuel even if the period of the attainment of full thermal load is long (n = 15 years). The effect of the dynamics of growth is expressed by the absolute value of economy in adjusted expenses $з_{эк}^{пр}$ which decreases as the length of the period of attainment of the full thermal load increases.

The results of the studies show that the degree of economy of district heating depends considerably also on climatic factors, particularly for TETs based on turbines of a relatively small unit power using solid fuel in most power systems with high-capacity GRES on organic fuel. For example, district heating on the basis of a T-100-130 turbine is economical for a TETs power of 200 MW and over in severe climatic conditions, and 400 MW and over in the southern regions of the USSR.

The effect of climatic conditions on the degree of economy of district heating is less substantial when a TETs uses the gas-mazut fuel. In this case, the effect of climatic conditions reflects on the economy of adjusted expenses which increases with transition to more severe climatic conditions. The effect of climatic factors increases when we consider the effects of the growth dynamics of thermal loads [4, 7].

Detailed studies have also been done on the determination of comparative economy of the development of district heating on organic fuel in large power systems developing on the basis of high-capacity AKES. It was considered that a large AKES-4000 with powerful atomic energy units VVER-1000 was replaced.

Considering that technical and economic indexes and studies of atomic sources of power supply are definitely conditional, particularly when they are considered as alternative sources of a combined scheme of power supply, it is practical to determine the marginal cost of nuclear fuel $з_{т.я}$ in a separate scheme of power supply under the condition that its degree of economy is equal to that of the combined scheme.

The marginal cost of nuclear fuel $з_{т.я}$ can be determined from the condition of the equality of adjusted expenses in the combined and separate schemes of power supply. The latter can be represented by the following expression:

$$З_к^{б.т} + з_{т.о} B_к = З_р^{б.т} + з_{т.я} B_{АКЭС} + з_{т.о} B_{р.к}, \qquad (1)$$

where B_k, $B_{АКЭС}$, $B_{p.k}$ -- fuel consumption in the combined scheme of power supply, at replaced AKES, and rayon boiler rooms of the separate scheme of power supply, thousand tons of reference fuel/year; $З_к^{б.т}$, $З_р^{б.т}$ -- adjusted expenses in the combined and separate schemes of power supply without the fuel component, thousand rubles/year; $з_{т.о}$, $з_{т.я}$ -- proportionate adjusted expenses on the organic and nuclear fuel, rubles/ton reference fuel.

From expression (1), it is easy to obtain proportionate adjusted expenses -- marginal cost of nuclear fuel $з_{т.я}$:

$$з_{т.я} = \frac{З_к^{б.т} - З_р^{б.т} - з_{т.о}(B_к - B_{р.к})}{B_{АКЭС}}. \qquad (2)$$

The results of studies on the determination of the comparative economy of TETs on organic fuel for a replaced AKES are shown in Figures 4 and 5.

Figure 4 shows the dependence of the marginal cost of nuclear fuel $з_{т.я}$ on the thermal load of the region Q_p for the climatic conditions of Yerevan when a TETs uses solid organic fuel, and Figure 5 shows the dependence on the climatological coefficient K_k for the operation of a TETs on the gas-mazut fuel and different costs of organic fuel.

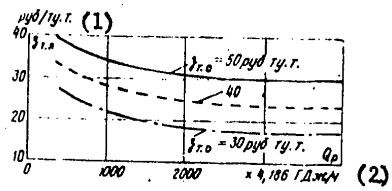

Figure 4. Dependence of the marginal cost of nuclear fuel $З_{Т.Я}$ on the thermal load of the rayon Q_p for the climatic conditions of Yerevan (TETs on solid organic fuel).
Thermal load Q_p =1670 ÷ 6700 GJ/h is covered by a TETs with T-100-130 turbines of 200-600 MW; Q_p=3760 ÷ 11300 GJ/h -- TETs with T-175-180 turbines of 350-1050 MW; Q_p = 4600 ÷ 16,700 GJ/h -- TETs with T-250-240 turbines of 500-1500 MW.
Key: 1. Rubles/ton reference fuel
2. GJ/h

The curves shown in Figures 4 and 5 are boundary curves separating the areas of economy of the combined and separate schemes of power supply. It is evident that the combined scheme is economical in the area above the curves, and the separate scheme of power supply is economical in the area below the curves (TETs and replaced rayon boiler rooms using organic fuel).

Analysis of the results of studies on the development of district heating in high-capacity developing power systems with large AKES makes it possible to conclude that, under the present conditions of the development and price formation in power engineering, district heating based on powerful district-heating turbines T-175-130, T-250-240 and others is absolutely economical for all regions of the USSR for the marginal cost of nuclear fuel of 15-17 rubles/ton reference fuel and higher if TETs use solid organic fuel and 9-10 rubles/ton reference fuel and higher if TETs use the gas-mazut fuel.

The curves shown in Figure 4 indicate that, as the thermal load of the rayon Q_p increases, the marginal cost of the fuel decreases, i.e., the economy zone of the use of district heating widens. For example, if the thermal load of the rayon Q_p = 2500 GJ/h, district heating is economical at the cost of nuclear fuel $З_{Т.Я}$ = 23 rubles/ton reference fuel and higher, and for Q_p = 12,500 GJ/h at $З_{Т.Я}$ = 17 rubles/ton reference fuel and higher (data for the climatic conditions of Yerevan for the cost of organic fuel $З_{Т.О}$ = 30 rubles/ton reference fuel). The above is explained by the fact that, as the thermal load of the rayon grows, the source of district heating (TETs) is enlarged, which makes it possible to use powerful district-heating turbine units. The economy zone widens substantially as the climatological coefficient K_k increases i.e., as we move to more severe climatic

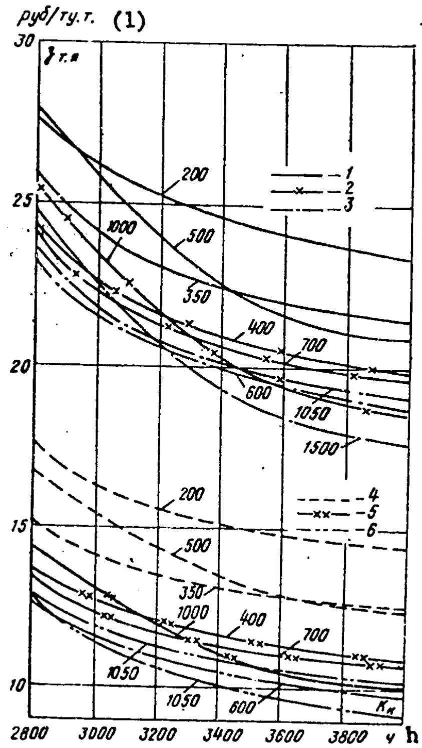

Figure 5. Dependence of the marginal cost of nuclear fuel $з_{Т.Я}$ on the climatological coefficient (TETs on organic gas-mazut fuel).
1-3 for $з_{Т.О}$ = 50 rubles/ton reference fuel; 4-6 for $з_{Т.О}$ = 30 rubles/ton reference fuel. Figures given on the curves designate electrical capacities of TETS, MW:
200—2×T-100-130; 250—2×T-175-130; 500—2×T-250-240; 400—4×T-100-130; 700—4×T-175-130; 1000—4×T-250-240; 600—6×T-100-130; 1050—6×T-175-130;

Key: 1. Rubles/ton reference fuel

conditions, particularly if a TETs uses the gas-mazut fuel (Figure 5). For example, district heating on the basis of the T-250-240 turbine is economical at the cost of nuclear fuel $з_{Т.Я}$ = 16 rubles/ton reference fuel and higher in the climatic conditions of Yerevan and 9 rubles/ton reference fuel and high in the climatic conditions of Yakutsk (data for TETs-1500 at the cost of organic fuel $з_{Т.О}$ = 30 rubles/ton reference fuel).

Studies show that the economy zone of the use of district heating narrows as the cost of organic fuel increases (curves in Figures 4 and 5). This conclusion is contrary to the generally accepted concepts of the development of district heating in power systems with large GRES using organic fuel. It is known that district heating produces a substantial saving in organic fuel connected with combined production of heat and electric energy in comparison with their separate production [4, 7-9]. The known concept is subject to a substantial correction when district heating develops on organic fuel in power systems with large AKES. In the latter case the use of the combined scheme of power supply leads to an overexpenditure of organic fuel in comparison with the separate scheme due to the consumption of organic fuel for the production of electric power [10]. As a result of this, the comparative economy of the combined scheme of power supply decreases as the cost of organic fuel goes up.

Conclusions

1. The degree of economy of district heating depends considerably on the value of the thermal load, its density, and the dynamics of its growth, the type and cost of fuel, as well as on the climatic factors.

2. The effect of the dynamics of the growth of thermal loads is substantial when the period of the attainment of the rated value by the thermal load is very long, particularly for turbines of relatively low unit power when TETs work on solid fuel in large power systems. The effect of the dynamics of the growth of thermal loads is not substantial when TETs operate on the gas-mazut fuel. District heating on the basis of powerful district-heating turbines is economical for all regions of the USSR even if the period of the attainment of the full thermal load is long.

3. The effect of climatic factors on the degree of economy of district heating is particularly substantial for TETs with turbines of a relatively low unit power when they work on solid fuel in large systems with powerful GRES. The effect of climatic conditions intensifies when the effects of the dynamics of the growth of the thermal loads is taken into account.

4. Under the conditions of the development of district heating in high-capacity developing power systems with large AKES, in the modern conditions of the development and price formation in power engineering, district heating based on powerful district-heating turbines T-175-130, T-250-240 and others is absolutely economical for all regions of the USSR at a marginal cost of the nuclear fuel of approximately 15-17 rubles/ton reference fuel and higher for TETs using solid fuel and 9-10 rubles/ton reference fuel and higher for TETs using the gas-mazut fuel.

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ELECTRIC POWER

CYLINDRICAL STRUCTURE FOR GAES

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 2, Feb 80 pp 50-54

[Article by O.V. Sitnin, engineer: "Cylindrical Structure for a Pumped-Storage Electric Power Plant"]

[Text] In the majority of instances pumped-storage electric power plants (GAES's) are situated on the banks of rivers and created or already existing reservoirs serve as the lower basin. As the upper basin is employed a natural depression or a basin created by earth dikes at high elevations of the bank.

The most complicated thing in creating a GAES is finding a suitable area for locating structures, for this area must meet the required topographical and geological requirements. These explorations are especially complicated in the central part of our country, where the geological structure of banks is characterized by moraine loam, clay and sand deposits, in the majority of cases inundated.

In evaluating conditions for the construction of structures of a plant center, of considerable importance are factors causing impairment of the bank's stability in the process of construction and operation. The creation of an upper water storage basin on banks sensitive to violation of their natural state and the positioning on them of conduits and GAES structures is complicated and labor intensive work.

The conditions for the erection of individual structures depend on the nature of the structure of their base and on the calculated characteristics of the soil.

It is necessary to take into account the possible additional inundation of the bank from the upper basin, as well as landslide phenomena, which can be evidenced after loading the bank with the structures placed on it and undercutting it when developing a foundation pit for the GAES structure. In recent years at the Gidroproyekt Institute [All-Union Scientific Research Institute of Planning of Hydroprojects imeni S.Ya. Zhuk] a great amount of work has been done on designing and finding structural solutions for structures of pumped-storage electric power plants for different conditions of arrangement. In one variant suggested by the writer of this article was designed a GAES structure of cylindrical form which can be of definite interest as a new type of this building structure with its own characteristic arrangement of key and auxiliary equipment.

The basic solution forming the basis of designing a structure of cylindrical form can be used in full or in part in the development of designs for GAES structures or for ordinary hyroelectric power plants downstream from dam and aqueduct hydroelectric power plants. The cylindrical GAES structure under discussion (fig 1), with six convertible hydroelectric power units, each with a capacity of 200 MW, in the structural respect is executed in the form of three coaxial vertical monolithic ferroconcrete cylinders which form the walls of the structure (fig 2).

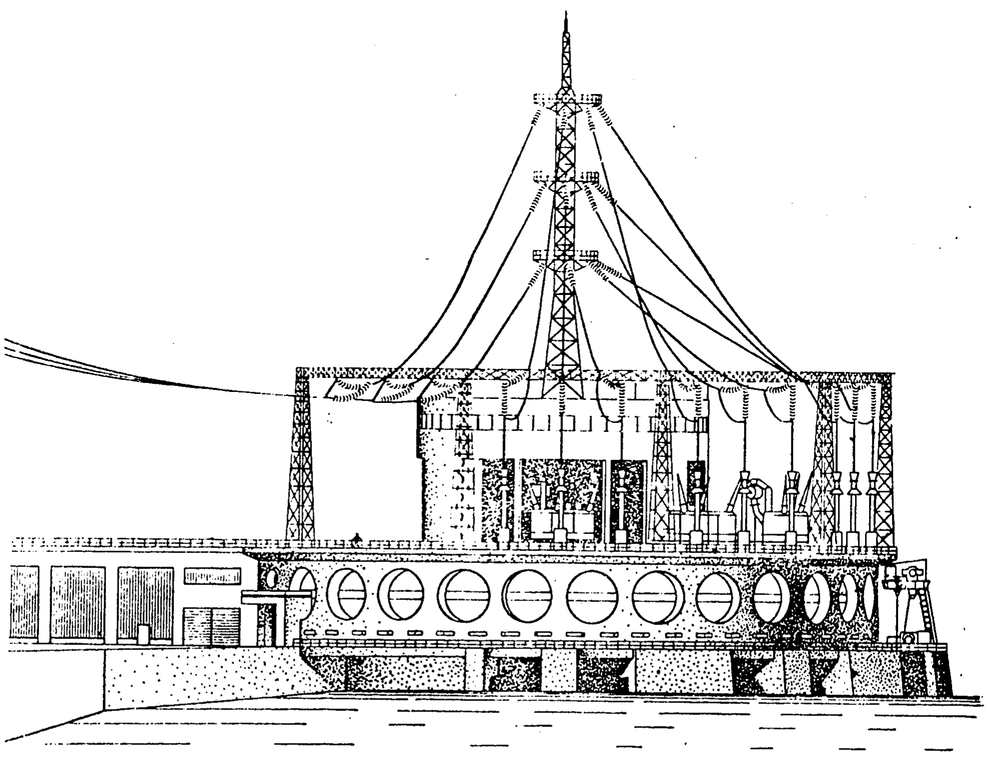
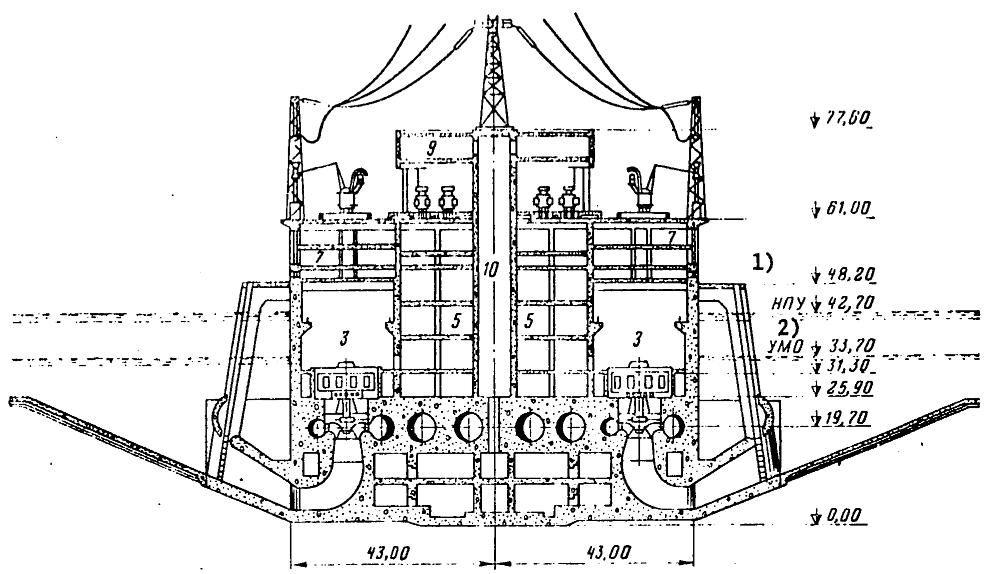
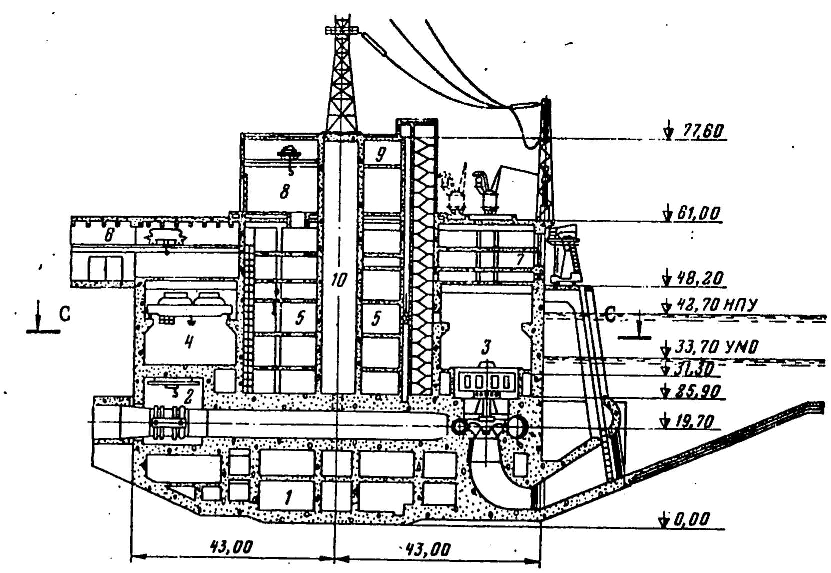


Figure 1. General View of GAES Structure (Architect: G.I. Vasil'yev)

A-A



B-B



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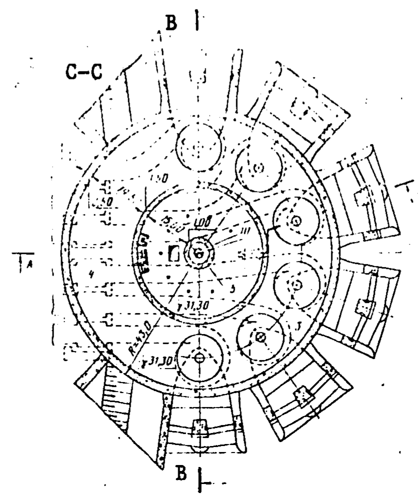

Figure 2. Sections of GAES Structure: 1--areas for auxiliary water power equipment and evacuation of units; 2--area for compensators; 3--engine room; 4--assembly area; 5--areas for electrical equipment; 6--outside area for freight delivery; 7--cable level and servicing production areas; 8--workshop for overhauling and inspecting transformers; 9--ventilation equipment area; 10--ventilation shaft

Key:
1. NPU [normal backwater level] 2. UMC [reference low-water level]

The horizontal members of the structure heightwise consist of monolithic and precast-monolithic ferroconcrete disk elements; the foundation slab, a block in which are placed the water conduits and vortex chambers of units, and the ceiling-floors of servicing production areas. The combination of these elements reliably insures rigidity of the structure, in which are absent the additional stiffening elements needed in structures of rectangular shape for resisting the influence of external loads, i.e., filling and the static pressure of the water. The dimensions of the GAES structure were determined on the basis of the distribution of the key and auxiliary equipment, the convenience of servicing it, and the location of servicing production areas. The main outside cylindrical wall with outside and inside radii of 43.0 and 40.5 m is 61.0 m high. In its upper section, above the maximum level of the water, the wall of the cylinder is

2 m thick and is lightened considerably by the window openings of the servicing production areas.

The middle cylindrical wall is 59.7 m high. In its lower section (to the concrete block for the turbine water conduits) the inside radius of the cylinder is 16 m, and 19.5 m above. Above the structure's roof representing a continuation of the cylinder is a superstructure 12.4 m high. In the center of the structure is a third cylinder 74.9 m high. In its bottom half the inside radius of this cylinder is 3 m, and 3.5 m above the water conduit block. The upper and lower sections of this cylinder, divided by the water conduit block, are connected by a through shaft 2 m in diameter.

Water is supplied to the vortex chambers through steel conduits 5.6 m in diameter, which, as are the vortex chambers, are located in the concrete block lying between the foundation section and the superstructure. At the points of connection of the penstocks and water conduits in the GAES structure are installed compensators for which a special area is provided in the structure. The suction pipes of the flow units are curved in a manner making possible smooth circulation of the flow. The exit cone section of the suction pipes projects cantileverwise from the main block of the structure. In the sluice section of the suction pipes, which surrounds the GAES structure in a ring, is provided a single row of inclined recesses for installing waste-retaining strainers and maintenance gates with a span of 8 m. The strainers and gates are serviced by a mechanism with a load lifting capacity of 2 X 200 tons, which moves along a circular track placed at the same level as the plant platform elevation.

The following arrangement of equipment and service areas has been provided. In areas located below the turbine conduits is located the auxiliary water power equipment: pumps and filters for the circulating water supply, pumps for evacuating the flow-through section of water power units, etc. In the turbine area above the turbine conduits are located compressors and high- and low-pressure air collectors. The engine room, in which are located the water power units in radial fashion with an angle of 36° between them, has in the plane a circular configuration and is bounded by the two concentric circular walls of the main and middle cylinder. The width of the engine room, 19.5 m, was determined by the conditions for the distribution of equipment and of parts when assembling and repairing water power units on the repair platform, which is a part of the engine room.

Provided in the engine room are two traveling cranes with a load lifting capacity of 640 and 100/80 tons with a span of 17 m each, on a circular track which makes it possible for them to independently go out to the repair platform. All freight is delivered to the repair platform via a hatch in the floor by a traveling crane with a load lifting capacity of 120 tons which has an exit to the external plant platform at which all freight arrives.

Above the GAES's engine room in three stories are areas with natural lighting. The bottom story is the cable level and on the other two are located the central control console, the all-plant relay station, the automatic control system, laboratories, electrical and turbine shops, ventilation space, etc.

Above these areas in the open air are located 250,000 kV·A step-up transformers combining lines, circuit breakers and dischargers.

Leading to the transformer platform on the structure is a ferroconcrete trestle along which pass an access road and rails for wheeling out the transformers (figs 3 and 4). In the section of the structure between the center and middle cylinders are located areas for electrical equipment. At the level of the turbine area are located rectifying transformers and closets for the conversion system for the thyristor excitation of generators, as well as cubicles for the center terminals of the generators. At the level of the engine room floor are switches for connecting the generators to the lines of the static frequency converter, and the unit panels. On the following stories are installed switches for automatically switching the units to the generator or motor modes and groups of circuit breakers, switches for static frequency conversion, sealing-off equipment for transformers for the GAES's internal needs, sections of complete distribution equipment, and complete transformer substations for the internal needs of blocks and the entire plant.

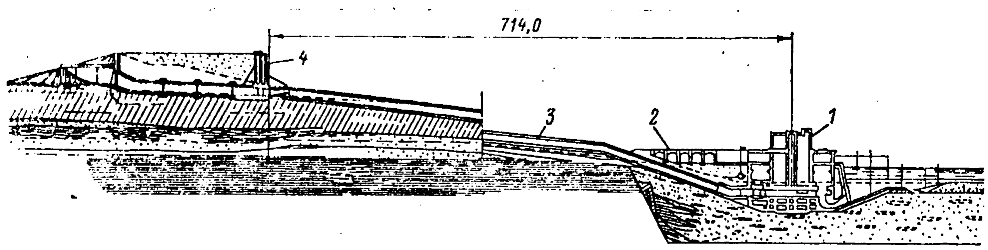

Figure 3. Lengthwise Cross Section Through Structures: 1--GAES structure; 2--ferroconcrete trestle; 3--conduits; 4--water intake

The main leads of the generators are connected to the leads of the step-up transformers by means of single-phase shielded conductors. Cable shafts are provided for running cables. Above the areas in which the electrical equipment is located, on the same level of the step-up transformers, is located a workshop for the inspection and repair of transformers. This workshop is equipped with a traveling crane with a load lifting capacity of 32 tons, which through hatches in the floors between stories can service all areas starting from the level of the turbine area and above. In the remaining section, in the niches, as it were, are installed transformers for the internal needs of the GAES and the power transformers for the frequency converter equipment. Serving as the roof for this equipment is the area in which the convective ventilation equipment is installed. The collected outside air for ventilation is distributed through the center cylinder connecting all stories of the structure. The engine room is exhausted by means of axial ventilators located in the outside wall of the structure, and areas at lower stories, via fixed air flues. Areas are connected vertically by means of stairways and elevators which exit to the structure's roof. A strong metal support installed on the center cylinder completes the GAES structure. This support is designed for suspending the electrical lines from the transformers to the ORU [outdoor distribution system] platform.

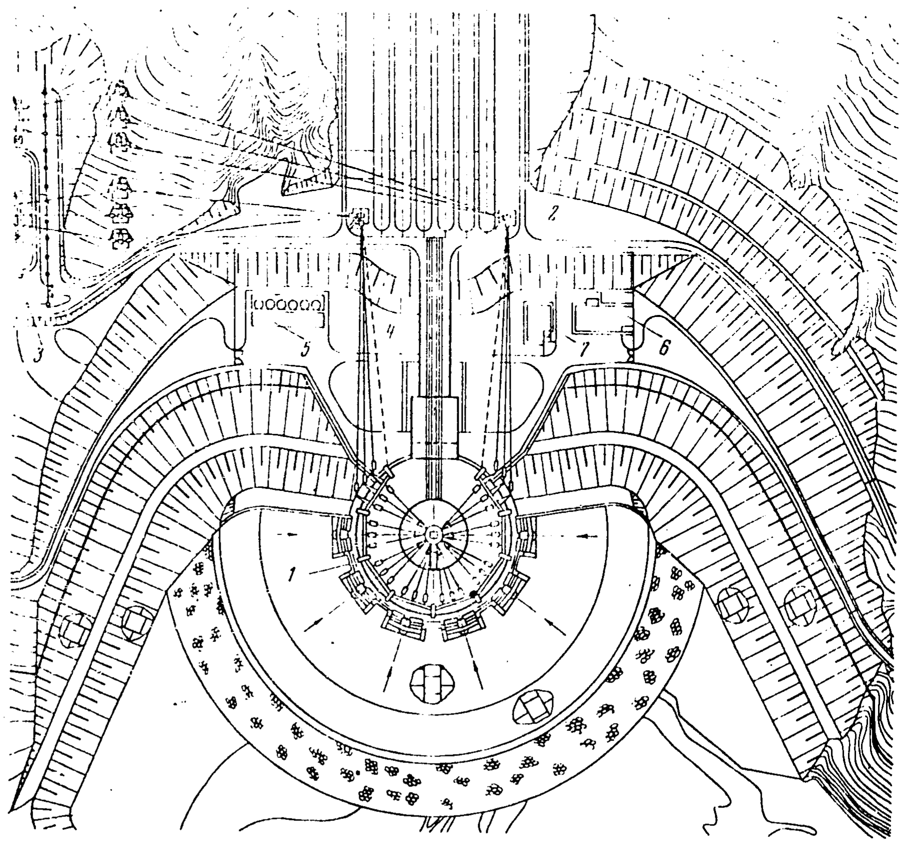

Figure 4. Plan of Plant Center: 1--GAES structure; 2--conduits; 3--ORU platform; 4--ferroconcrete trestle; 5--central oil plant; 6--servicing production building; 7--dining room

In this type of GAES structure the following advantages can be discerned: The length of the supported embankment is reduced as compared with an ordinary frontal structure; the assembly area is located inside the GAES structure, without requiring a separate building for the assembly and repair of equipment; within the confines of the GAES structure are accommodated areas for all technological services, in connection with which the need for buildings for auxiliary production purposes is practically done away with; the amount of excavation in the foundation pit is considerably reduced; the radial distribution of the water power units extends the front for spreading or piling up the flow, which results in a reduction in the rates of flow of the water and, as a consequence, in a reduction in the amount of reinforcement in the tailrace.

The design solution described can be adapted to different specific conditions and can find application in designing water power projects.

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FUELS

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RELIABILITY ANALYSIS OF PROSPECTIVE GAS RESERVES

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 1, Jan 80 pp 30-33

[Article by A. A. Gorelov and O. I. Filonenko, TyumenNIIGiprogaz: "Methodology for Analyzing the Confirmation Rate of Prospective Gas Reserves -- Using the Example of the Northern Regions of Tyumenskaya Oblast"]

[Text] Analysis of the confirmation rate of prospective reserves enables us to clarify the reliability of the estimates of them. The estimate figures are crucial in determining the efficiency of prospecting and exploration and the correctness of planning the growth of industrial reserves and recovery of gas.

The present methodology of analysis permits determination of that part of category C_2 reserves which is genuine and transferred to a higher industrial category during the time segment under study [1-3]. We are proposing variations of this methodology that will make it possible to trace changes in the confirmation rate of prospective reserves of the study region over time. To do this the period of time for which the confirmation rate of reserves is being analyzed may be broken down into distinct periods of increasing length, decreasing length, or constant length (see Figure 1, next page).

For an increase in the length of periods the starting point of the analysis is the year in which the prospective reserves of the first report site of the region under consideration are taken onto the balance (or any other year), and the final date is 1 January of each subsequent year. In this case the confirmation rate of reserves is determined for different time segments (each subsequent period is one year greater than the one before), but this does permit tracing changes over time.

For periods of decreasing length the starting point of analysis is 1 January of each subsequent year beginning at the time when the reserves of the first report site of the study region are included in the balance, and the final date is 1 January of the last year in which there are reserve balances (for example, 1 January 1978).

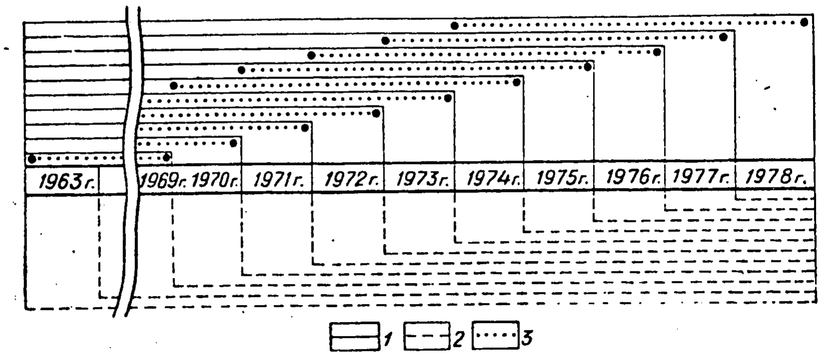

Figure 1. Diagram of the Analysis of Change in the Confirmation Rate of Prospective Reserves over Time. Length of Periods Analyzed: (1) Increasing; (2) Decreasing; (3) Constant (Five Years)

Because each subsequent period is one year less than the preceding one in this case, it is possible to analyze the confirmation rate of reserves with different degrees of study of the region, that is, in different stages of prospecting and exploration.

For the constant period length a definite interval of time, for example three or five years, is used to evaluate the confirmation rate of reserves.

A multifaceted analysis of the confirmation rate of category C_2 gas reserves using this scheme was made for prospective structures and deposits in the northern part of Tyumenskaya Oblast (the Yamal, Gyda, Pur-Taz, and Nadym-Pur oil-gas fields). On 1 January 1978 more than three-fourths of reserves in industrial categories were prospective reserves of free gas. Most (67 percent) of the reserves were at already-discovered gas and gas condensate deposits (counting unopened horizons) and the rest (33 percent) was in prospective structures. We analyzed 36 structures and 35 deposits at which changes occurred in category C_2 reserves as the process of prospect and exploratory drilling went forward and geological and geophysical findings were reinterpreted.

The confirmation rate of reserves was evaluated by a coefficient that was the ratio of reserves in categories A, B, C_1 and ΔC_2 to C_2 reserves [2, 3]. This coefficient gives the maximum value of the confirmation rate that can be attained if the remaining C_2 reserves at the final date of analysis (ΔC_2) are completely confirmed and moved to industrial categories without change.

The volume of reserves analyzed for categories A, B, and C_1 included only those that came from exploration of category C_2 reserves. For deposits they were calculated as the difference between reserves in categories A, B, and C_1 on the starting and final dates of the period of analysis. The coefficients of confirmation rate were determined relative to the maximum estimate of C_2 reserves for any year of the study period for producing horizons of deposits where exploration was not completed and for structures before drilling was begun or before reinterpretation of geological and geophysical materials. In computing the average values of the coefficients of the confirmation rate first all the deposits or prospective structures being analyzed were considered, then the largest ones were excluded (see Figure 2).

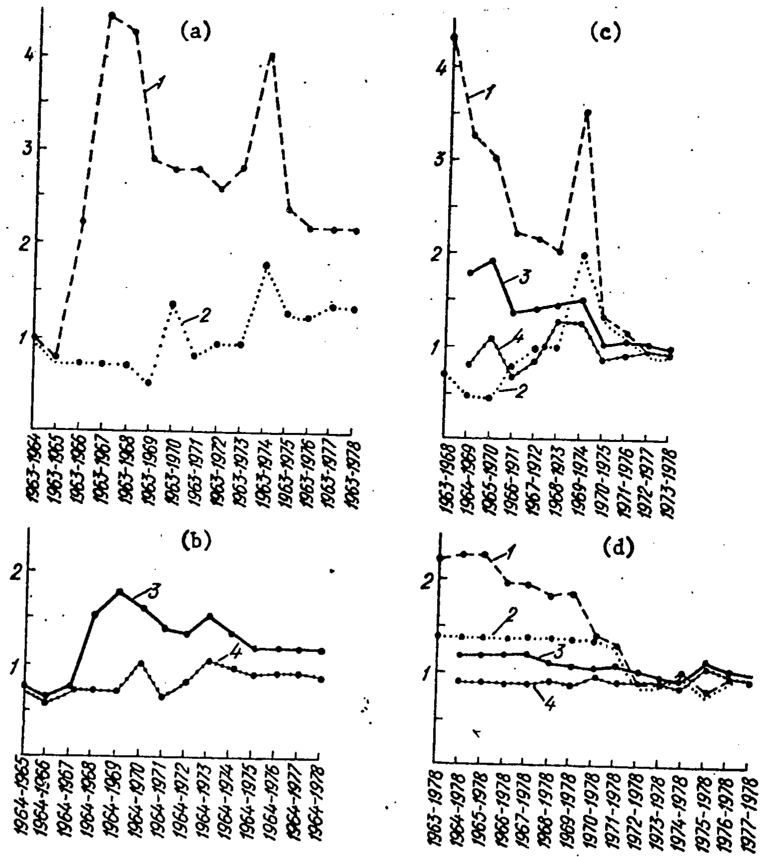

Figure 2. Dependence of Coefficients of Confirmation Rate of Total Reserves of C_2 Gas Reserves at Prospective Structures and Deposits of Northern Tyumenskaya Oblast on Length of Periods Analyzed -- (a) and (b) Increasing Period Lengths; (c) Constant (Five Years); (d) Decreasing Period Lengths

Key: (1) All Structures; (2) All Structures but Zapolyarnaya, Medvezh'ye, and Yamburg; (3) All Deposits; (4) All Deposits but Urengoy, Medvezh'ye, Zapolyarnyy, and Yamburg.

The charts show that the values of the coefficient of confirmation rate of total category C_2 gas reserves for these prospective structures and deposits in northern Tyumenskaya Oblast vary widely. They are higher for the prospective structures than for the deposits. This applies especially to the periods of analysis covering the initial phase of prospecting and exploration. Thus, the figure for the prospective structures sometimes reaches 4.29-4.43, while for deposits it is no more than 1.75. For the periods of analysis that include the final years of prospecting and exploration (1972-1978), the values of the coefficients vary only slightly.

Two maximums can be identified in the graphs of change in the coefficients of confirmation rate of reserves of prospective structures for periods of increasing (Figure 2a) and constant (2c) length. The first is caused by the high rate of confirmation of reserves at the Zapolyarnaya and Medvezh'ye structures and the second the high rate at the Yamburg and Bovanenkovskiy structures. The original estimate of category C_2 gases there proved greatly understated. As a result, the coefficients of confirmation rate at these structures on 1 January 1978 were, respectively, 25.9, 4.1, 15.6, and 8.7.

The overall confirmation rate of category C_2 deposits for this region is also increased by the Urengoy, Medvezh'ye, Zapolyarnyy, and Yamburg deposits. If the large structures and deposits are excluded in computing the average confirmation coefficients the figures drop considerably (see Figure 2). This gives reason to think that it would be wise, when planning growth in industrial reserves and recovery of gas in regions where the discovery of small and medium-sized deposits is expected, to take account of the patterns of change in the coefficients of confirmation rates of reserves calculated for similar sites; that is, large structures and deposits should be excluded in this case. Attention here should be focused on analysis of the confirmation rate of reserves for the last years of prospecting and exploration. The periods of decreasing and constant length are especially interesting, because they permit exclusion of the initial phase of prospecting and exploration when the region has been relatively little studied.

Thus, the proposed variations permit a determination of the coefficients of rate of confirmation of total reserves of category C_2 gas at prospective structures and deposits of the study region for time intervals of different length and clarification of the basic patterns of change, which helps plan growth in industrial reserves and recovery of gas more correctly.

FOOTNOTES

1. Melik-Pashayev, V. S., Breyev, V. A., Voronova, G. T., and Kochetov, M. N., "Analysis of the Confirmation Rate of Reserves of Oil in Categories C_1 and C_2 Transferred to Higher Categories,"

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FUELS

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WATER CONTENT OF OUTPUT FROM WATER-DISPLACEMENT RECOVERY

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 1, Jan 80 pp 44-48

[Article by M. M. Ivanova, V. A. Timofeyev, Yu. I. Bragin, and L. A. Degtyareva, MINKhiGP: "Water Content of Output Extracted from Pools by Water Displacement"]

[Text] In the last decade more publications have appeared that summarize experience with exploitation of long-operating oil pools using water displacement, both for particular regions and for the country as a whole [1-5]. The reliability of the conclusions reached and trends identified improves as the number of pools in the final stage of exploitation increases and the range of geological and physical conditions of the pools analyzed broadens.

There are 116 significant pools in the concluding stage of exploitation at different oilfields in our country today, 56 using artifical displacement of oil by water and 60 using natural water displacement.

This article will review certain results of a comparative analysis of the indexes of exploitation at these pools. Primary attention focuses on changes in the water content of the output of the pools in different geological and physical conditions because this index is the key characteristic of the water displacement process and is conditioned by the magnitude of final petroleum extraction.

Figure 1 (next page) depicts typical curves, for the group of pools studied, of the water content of output depending on pteroleum extraction. The curves take up a large area on the graph, which indicates the differences in the nature of the increase in the water content of output from different pools.

Most of the curves, especially in the middle and righthand parts of the figure, differ by inclination (slope), which shows different rates of increase in the water content of output. The initial part of the curve shows slow growth, followed by intensive growth in the middle and slowed-down at the end.

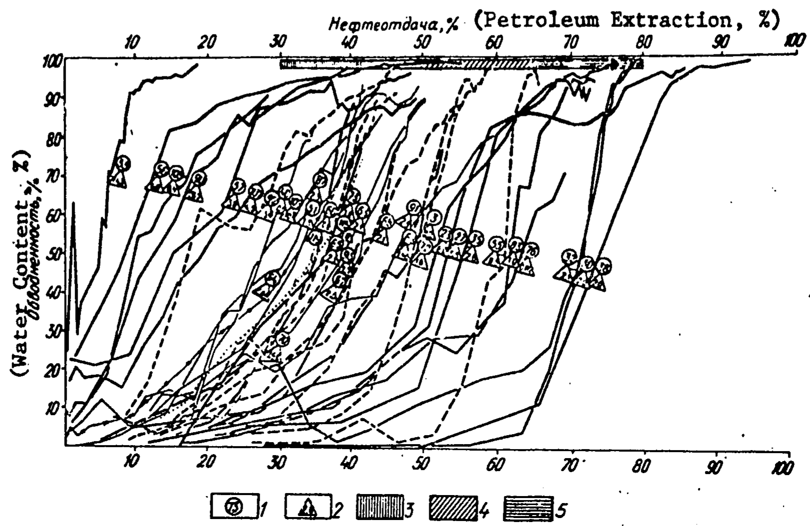

Figure 1. Water Content of Output Recovered from Pools

Key: (1) Number of Deposit;
(2) Relative Viscosity of Petroleum;
(3) Limits of Final Petroleum Extraction for Group No 1;
(4) Limits of Final Petroleum Extraction for Group No 2;
(5) Limits of Final Petroleum Extraction for Group No 3.

[Specific Pools]

a. Pools of Low-Viscosity Oil (μ_o<1) with Small Oil-Bearing Area (to 5,000-6,000 ha) and Relatively Uniform Structure (k_p<2.5):

3 -- Kala, west field, PK;
21 -- Yasamal'skaya Valley, PK_1;
23 -- Surakhanskaya, central field, PK_2;
27 -- Chakhnaglyar, PK_2;
30 -- Oktyabr'skaya, XVI;
32 -- Oktyabr'skaya, XIII;
35 -- Tashkalinskaya, XII;
38 -- Oktyabr'skaya, XXII;
55 -- Kulsary, primary layer XIV, Permian-Triassic horizon;
76 -- Kuleshovskaya, A_3;

b. Pools of Low-Viscosity Oil (μ_o<4) with Small Oil-Bearing Area (to 5,000-6,000 ha) and Non-Uniform Structure (k_p>2.5) or Large (more than 5,000-6,000 ha) Area of Oil-Bearing and Water-Oil Zones:

51 -- Neftegorskaya, VI;
61 -- Palazinskaya, Yasnopolyanskiy Horison;
63 -- Tuymasinskaya, D_1;
64 -- Shkapovskaya, D_{II};
66 -- Shkapovskaya, D_{IV};

[Key continued, next page]

[Key continued]

67 -- Serafimovsko-Leonidovskaya, $D_o + D_1$;
68 -- Aleksandrovskaya, D_1;
69 -- Konstantinovskaya, D_{II};
70 -- Konstantinovskaya, D_I;
72 -- Bavlinskaya, D_1;
73 -- Kuleshovskaya, A_4;
83 -- Zol'nenskaya, B_2;
87 -- Khilkovskaya, $C_{I + II}$;
89 -- Strel'nenskaya, $B_2 + B_3$;
91 -- Zhigulevskaya, D_o;
95 -- Blagodarovskiy Dome, A_4;
109 -- Bakhmet'yevskaya, A_2;
111 -- Kochanovskaya, P_3;
119 -- Tungorskaya, XX;

c. Deposits of More Viscous Oil (μ_o>4):

53 -- Makat, North, Jurassic Horizon I;
56 -- Teren-Uzyuk, Cenomanian Horizon 57;
57 -- Baychunas, primary layer, Neocomian Horizon;
90 -- Syzranskaya, B_2;
92 -- Karlovo-Sytovskaya, $B_1 + B_2$;
105 -- Bakhmet'yevskaya, Lower Bashkir Horizon;
107 -- Archedinskaya, Bobrik Horizon.

The relative position of the middle part of all the curves is close to parallel; greater distance from the ordinate axis indicates an increase in the initial period of work of pools with low water content and a decrease in the final period of operation with high water content. As a result the curves acquire a characteristic configuration. In the righthand and middle parts of the figure they are concave relative to the ordinate axis, and in the lefthand part they are convex.

This difference is explained above all by the relative viscosity of layer oil μ_o (the ratio of oil and water viscosity under layer conditions).

The curves for pools with relative viscosity of less than four are mostly located in the righthand and middle parts of the figure; the curves on the left are for pools with greater viscosity. This confirms, for a large number of sites, the conclusion reached earlier in work [1] that a relative viscosity of about four can be considered the dividing line between low and higher viscosities.

The curves corresponding to low-viscosity pools occupy a significant part of the graph for the small range of relative viscosities between 0.5 and four. At the same time for higher viscosity, despite the much greater range of values (4-143), the curves of water content are much more dense. This may be explained by the fact that at low oil viscosity the absolute viscosity values have a greater impact on change in water content than at high viscosities. In addition, the higher oil viscosity, especially at very high values, eclipses (so to speak) other geological and physical factors.

At low viscosity the role of other geological and physical factors is very great. This is reflected also in the greater dispersion of the curves. Change in the water content of the output of pools here depends significantly on the geological heterogeneity of the producing layers (dissection of the exploitation unit, which is statistically linked to arenosity [sandiness]). The influence of this dissection can also be seen by comparing the curves of water content of the output of pools with similar oil viscosity, layer D_0 at Zhigulevskiy (91)*, D_1 at Bavlinskiy (72), and S_{I+II} at Khilkovskiy (87) and D_1 at the Aleksandrovskiy site (68). The curves of water content of pool output located toward the right correspond to layer D_0 at Zhigulevskiy and D_1 at Bavlinskiy with relatively monolithic structure. The curves for pools S_{I+II} at Khilkovskiy and D_1 at the Aleksandrovskiy site are toward the left owing to greater heterogeneity of layer structure (their dissection factors are 3.3 and 2.0).

Less geological heterogeneity promotes a longer low-water period for two reasons. On the one hand, more of the layers can be flooded, and other the other, with small pool dimensions and low oil viscosity it is possible to work the water-oil zones largely without drilling, by displacing the oil with water and forcing the oil toward wells located within the inner contour of the field. This reduces the amount of water taken from the layers.

Thus, a comparative analysis of the curves shows that within the pools of low-viscosity oil higher rates of increase in the water content of output are linked to increase in the relative viscosity of the oil, the geological heterogeneity, and the dimensions of the water-oil zones. For pools with higher oil viscosity this has a decisive effect on water content.

Several industrial factors influence changes in the water content of output from pools (see Figure 1).

The well networks have a significant impact. It is especially noticeable for pools with relative oil viscosity between four and six. For less dense networks (more than eight hectares per well) the curves of change in the flooding of the pools were convex. When drilling was done with networks of up to 2-4 hectares per well the curves of the water content of the units (suite PK of the northwestern field at the Kala deposit, suite PK_2 of the central field of the Surákhany deposit and others) are similar to the curves of water content of pools of low-viscosity oils.

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* The numbers in parentheses correspond to the numbers in Figure 1.

Overall, when the density of the well network is increased where the water content of output is constant there will be somewhat more petroleum extraction. This points up the need for careful substantiation of the density of the well network during the planning and exploitation of every layer with a spread-out network.

Experience shows that using forced takeoffs of liquid from the flooding wells from the moment that extraction at the pool begins to drop accelerates the increase in water content of output. For example, forced liquid takeoff from the pool of layer XII at the Tashkalinskiy deposit (35) beginning at the start of the second phase of exploitation set the curve of water content considerably back to the left of the curves for the pools of layers XIII and XIV of the Oktyabr'skiy deposit (32, 30) which have similar characteristics and are worked by the same system.

The degree of use of reserves extracted in the primary period, which determines final petroleum extraction to a significant extent, depends largely on the effectiveness of the third stage of exploitation.

The assigned rate of oil recovery is achieved in the third stage, of course, by insuring the necessary takeoff of liquid corresponding to the change in water content. Inadequate takeoffs cause excessive decrease in oil recovery in this stage and at the end of the primary period with inadequate use of reserves.

To substantiate the necessary change in takeoff of liquid it is important to foresee water content of output at the end of the third stage. This makes is possible to substantiate both the necessary number of operating wells at the end of the primary period and the set of industrial steps required to insure takeoff of the liquid.

In view of the greatly increased number of sites that have entered the concluding stage, consideration of this issue necessitates corrections in the earlier [1] estimate of water content at the end of the primary period for pools with different characteristics. Figure 2 (next page) shows water content in the output of sites studied with adequately full use of reserves by the end of the primary period of exploitation. Small-sized pools of low-viscosity ($\mu_o<1$) occurring in moderately dissected layers ($k_p<2.5$) conclude the primary stage of exploitation with water content in the range 30-60 percent. For pools of low-viscosity oils ($\mu_o<4$) in layers with greater heterogeneity ($k_p>2.5$) or large oil-water zones the water content by the end of the primary period of exploitation reached 60-85 percent. For sites with higher oil viscosity the water content of output by the end of the third stage usually exceeds 85 percent.

The broad range of values for water content in pools is caused in large part by geological and physical factors and the rate of liquid

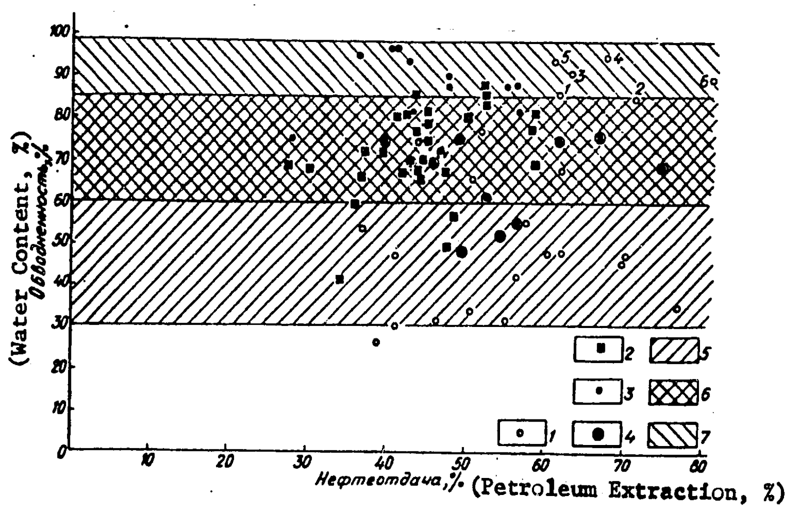

Figure 2. Water Content of Output by the End of the Third Stage

Key: (1) Pools of Low Viscosity Oils (μ_o<1) with Small Oil-Bearing Area (to 5,000-6,000 ha) and Relatively Uniform Structure (k_p<2.5);
(2) Pools of Low-Viscosity Oils (μ_o<4) with Small Oil-Bearing Area (to 5,000-6,000 ha) and Heterogeneous Structure (k_p<2.5) or Large Oil-Bearing Area (more than 5,000-6,000 ha) and Oil-Water Zones;
(3) Pools of Oils of Higher Viscosity (μ_o>4);
(4) Pools with Relative Viscosity of Layer Oil of 4-6, with Networks of Less than 8 ha/Well;
(5) Water Content of 30-60 Percent;
(6) Water Content of 60-85 Percent;
(7) Water Content of 85-100 Percent.

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takeoff in the third stage. This range of values for water content can be explained to some degree by inaccuracies in computing balance reserves of oil. It should also be noted that the decrease in rate of liquid takeoff causes a drop in the water content of output toward the end of the primary period but this is accompanied by a rapid drop in oil recovery in the third stage and, consequently, inadequate realization of reserves by the end of the primary period.

The sharp increase in liquid takeoffs by forcing in the third stage promotes maximum use of reserves in the primary period, especially for pools with higher oil viscosity and heterogeneous layer structure. At the same time it causes growth in the water content. Forcing on a large scale causes the water content to go far beyond the bounds of its range of values for the corresponding group of pools.

Thus, intensive liquid takeoffs from several sites at low-viscosity pools in the Chechno-Ingushskaya ASSR and Azerbaijan (1-6) led to an increase in water content by the end of the third stage all the way to the water content levels of sites with higher oil viscosity, that is, more than 85 percent.

Therefore, the following average values may be adopted as rough guidelines for the water content of output by the end of the primary period when the rate of liquid takeoff has been correctly established: for small sites with low-viscosity oil (μ_o<1) in weakly dissected layers (k_p<2.5) -- 40-50 percent; for sites with low-viscosity oil (μ_o<4) in layers that have greater heterogeneity (k_p>2.5) or large oil-water zones -- 70-80 percent; for sites with higher oil viscosity -- 80-90 percent.

From the above one may draw the following conclusions.

1. Study of changes in the water content of output from pools at a large number of sites confirms that the nature of this variation depends first of all on the relative viscosity of the layer oil. The boundary value can be taken as approximately four.

2. With low oil viscosity the rate of growth in water content of output increases with greater geological heterogeneity of the layers and dimensions of the water-oil zone, with less dense well networks, and expansion of the scale and time of forced liquid takeoff. For pools with higher viscosity this characteristic overshadows the impact of other geological and physical factors; for pools with this kind of oil forcing takeoffs, accompanied by a rise in the water content, promotes greater petroleum extraction.

3. An improvement in the geological and physical characteristics of pools leads to greater petroleum extraction during both the period of low water content and the entire period of exploitation.

FOOTNOTES

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FUELS

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TYPES OF OIL, GAS POOLS OF SIBERIAN PLATFORM

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 1, Jan 80 pp 1-5

[Article by V. N. Vorob'yev, SNIGGIMS: "Types of Oil and Gas Pools in the Precambrian and Lower Paleozoic Beds of the Siberian Platform"]

[Text] Nine industrial deposits of petroleum and gas have now been identified in the beds of the Upper Precambrian and Lower Paleozoic of the Siberian platform. They are concentrated in the southern, best-studied regions: the Nepsko-Botuobinskiy and Baykitskiy anteclises and the Angara-Lena bench (see Figure 1). In addition, several structures with industrial flows of oil and gas in certain wells have been identified there. Various published works have treated the questions of the structure of certain deposits or their location [1-6].

Known accumulations of hydrocarbons have been found in three gas and oil complexes: the Lower Middle Cambrian halogenic-carbonate complex which joins beds of the Litvintsevskiy and Usol'sk suites and the Upper-Middle Motskiy subsuites; the Vendian-Lower Cambrian terrigenous within the Lower Motskiy subsuite, and the Riphean terrigenous-carbonate complex. The latter is divided from the Cambrian beds overlying it by a regional discontinuity.

Productive horizons have been identified in all of these complexes: the Osinskiy and Yuryakhskiy horizons (the lower part of the Usol'sk suite) in the first, the Upper Tirskiy, Parfenovskiy, and Botuobinskiy (Lower Motskiy subsuite) in the second, and the Yaraktinskiy, Bokhanskiy (Ushakovskiy suite), Kharyastanskiy (Kharyastanskiy suite), Vilyuchanskiy (Vilyuchanskiy suite), and numerous unnamed horizons in the unbroken Riphean layer at the Kuyubinskiy site in the third.

The oil and gas deposits usually have one or two pools. The total number of industrial pools identified is 16: one of them is an oil pool, five are oil and gas condensates, and nine produce gas and gas condensate (see Table 1 below).

Table 1. Distribution of Deposits by Oil-Gas Complexes

Deposits	Complexes		
	Lower-Middle Cambrian	Vendian-Lower Cambrian	Riphean
Atovskiy	--	Parfenovskiy (GC)	Bokhanskiy (GC)
Bratsk	--	Parfenovskiy (GC)	--
Markovskiy	Osinskiy (P)	Parfenovskiy (GC)	--
Yaraktinskiy	--	--	Yaraktinskiy (PGC)
Ayanskiy	--	Upper Tirskiy (GC)	Yaraktinskiy (PGC)
Middle Botuobinskiy	Osinskiy (G)	Botuobinskiy (Parfenovskiy (PGC)	--
Upper Vilyuchanskiy	Yuryakhskiy (G)	--	Kharystanskiy (G)
Vilyuysk-Dzherbinskiy	Yuryakhskiy (G)	--	--
Kuyumbinskiy	--	--	unnamed (PGC)

Pools: (G) Gas; (GC) Gas Condensate; (PGC) Petroleum-Gas Condensate; (P) Petroleum.

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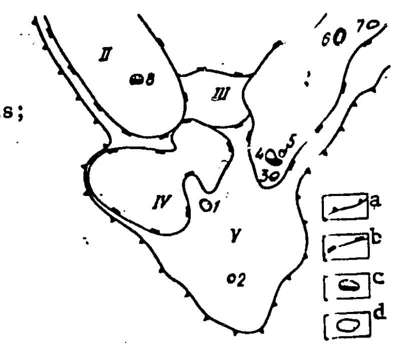
Figure 1. Diagram of the Location of Oil and Gas Deposits in Pre-Cambrian and Lower Paleozoic Beds of the Siberian Platform

Key: (a) Boundaries of the Siberian Platform;
(b) Outlines of Large Structures;
(I) Nepsko-Botuobinskiy Anteclise;
(II) Baykitskiy Anteclise;
(III) Katanga Saddle;
(IV) Sayan-Yenesey Syneclise;
(V) Angara-Lena Bench;
(c) Petroleum-Gas Condensate Deposits;
(d) Gas and Gas Condensate Deposits;
(1) Bratsk;
(2) Atovskiy;
(3) Markovskiy;
(4) Yaraktinskiy
(5) Ayanskiy;
(6) Middle Botuobinskiy;
(7) Upper Vilyuchanskiy;
(8) Kuyumbinskiy.



Despite the limited number of pools found, their structure varies quite broadly owing to differences in the composition of the rock in strata of different age and in the structure of different regions.

The pools are controlled by anticlinal and non-anticlinal (monoclinal) structures. A distinction is made between layered and compact pools depending on type of reservoir. Finally, pools are distinguished by the morphology of the trap: arching, lithologically bounded, stratigraphically screened, and other types (see Table 2).

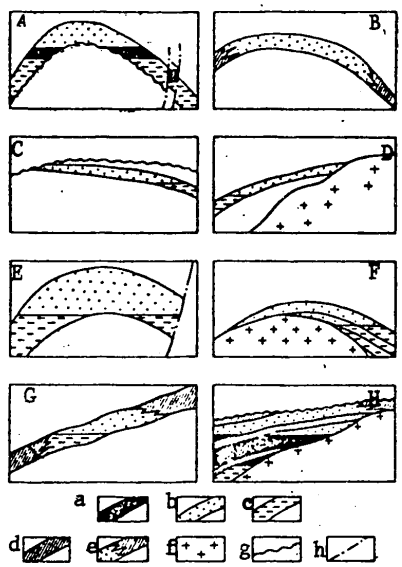
Anticlinal type pools are found at the Atovskiy, Bratsk, Middle Botuobinskiy, Upper Vilyuchanskiy, and Vilyuy-Dzherbinskiy deposits. Arch-type traps are most typical, frequently with elements of lithological replacement or tectonic screening (see Figure 2 below). Stratigraphic screening of the "head" of the productive layer by a discontinuity surface plays a significant role in the group of anticlinal deposits, as is demonstrated at the Kharystanskiy pool of the Upper Vilyuchanskiy deposit (see Figure 2C). Cases of productive horizons stratigraphically justaposed to outcroppings of the crystalline basement are characteristic of the Bokhanskiy pool of the Atovskiy deposit (see Figure 2D) and the Vilyuchanskiy pool of the Upper Vilyuchanskiy deposit (see Figure 2F)

Non-anticlinal pools are identified at the Markovskiy, Yaraktinskiy, Ayanskiy, and apparently Kuyumbinskiy deposits. They are controlled

Table 2. Classification of Pools by Nature of Structural Control and Type of Reservoirs and Traps

Nature of Structural Control	Type of Reservoir	Type of Trap	Examples of Pools (Deposits)
Anticlinal	Layered	Arch	Botuobinskiy (Middle Botuobinskiy, Figure 2A)
"	"	Arch, Lithologically Bounded	Parfenovskiy (Atovskiy), Kharystanskiy (Eastern Block of Upper Vilyuchanskiy, Figure 2B)
"	"	Hanging, Stratigraphically Screened by Unconformity Surface	Kharystanskiy (Western Block of Upper Vilyuchanskiy, Figure 2C)
"	"	Hanging, Stratigraphically Screened by Basement Outcrop	Bokhanskiy (Atovskiy, Figure 2D)
"	Compact	Arch	Parfenovskiy (Bratsk, Figure 2E)
"	Compact	Arch, Stratigraphically Screened by Basement Outcrop	Vilyuchanskiy (Upper Vilyuchanskiy, Figure 2F)
Monoclinal	Layered	Lithologically Bounded	Parfenovskiy (Markovskiy, Figure 2G), Upper Tirskiy (Ayanskiy)
"	Compact	Lithologic-Stratigraphic	Yaraktinskiy (Yaraktinskiy, Figure 2H)

Figure 2. Examples of Oils and Gas Pools.



Key: Types of Pools:
(A) Botuobinskiy (Middle Botuoubinskiy Deposit);
(B) Kharystanskiy (Eastern Block of Upper Vilyuchanskiy);
(C) Kharystanskiy (Western Block of Upper Vilyuchanskiy);
(D) Bokhanskiy (Atovskiy);
(E) Parfenovskiy (Bratsk);
(F) Vilyuchanskiy (Upper Vilyuchanskiy);
(G) Parfenovskiy (Markovskiy);
(H) Yaraktinskiy (Yaraktinskiy);
Types of Reservoirs:
(a) Oil-Saturated;
(b) Gas-Saturated;
(c) Water-Saturated:
(d) Impermeable Interlayered;
(e) Lithologic Replacements;
(f) Basement Rocks;
(g) Surface of Stratigraphic Unconformities;
(h) Disjunctive Dislocations.

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by monoclinal slopes of first and second order uplifts. Lithologically bounded traps formed as the results of local improvement of the collector properties of productive horizons are most widespread. The

Parfenovskiy pool at the Markovskiy deposit and the Upper Tirskiy pool at the Ayanskiy deposit (see Figure 2g) are among such structures. The pools in the beds of the Yaraktinskiy band at the Yaraktinskiy and Ayanskiy deposits are controlled by traps of a more complex, lithologic-stratigraphic type. In addition to local increases in the capacity and filtration properties of the rocks, it is important in the structure of these pools that the productive layers are stratigraphically juxtaposed to the surface of the crystalline basement (see Figure 2h).

The pools at the Kuyumbinskiy deposit are classified as non-anticlinal stratigraphically screened. The screening of the productive layers there is accomplished by the surface of a Precambrian discontinuity. The reservoir is most likely a layer type.

The pools of the Osinskiy productive horizon at the Markovskiy and Middle Botuobinskiy deposits are compact lithological pools. The accumulations of hydrocarbons are controlled there by increased jointing and secondary leaching of rocks zones of tectonic deformation. Linear orientation and a low degree of stratification of intervals of oil and gas saturation are typical features of these pools. Thus, even though the Osinskiy pool of the Middle Botuobinskiy deposit is associated with an anticlinal uplift, it cannot in fact be classified as an anticlinal type of pool because it is not controlled by the bending of the layers, but rather by a zone of heightened rock jointing in the western subaxial part of the structure.

The survey of types of oil and gas pools we have made allows us to outline the basic patterns in their lateral and stratigraphic distribution. In addition to traps controlled by anticlinal uplifts, non-anticlinal stratigraphic, lithologic, and lithologic-stratigraphic traps are extensively developed in the Precambrian and Paleozoic beds of the region.

The identification of stratigraphic traps where structures lie against and over outcroppings of the crystalline basement is most likely in the basal horizons of the Vendian-Lower Cambrian and Riphean oil and gas bearing complexes. Promising zones for possible development of them are the slopes of anteclises and inherited first-order uplifts and sectors with high gradients of change in the thicknesses of terrigenous beds and differentiated hypsometric readings for the surface of the crystalline basement. In this respect the articulation zone of the Nepsko-Botuobinskiy and Baykitskiy anteclises with the adjacent structures of foredeeps, syneclises, and the largest inherited basins are especially interesting.

The stratigraphic pools screened by the surface of the Precambrian regional discontinuity gravitate to the upper, eroded part of the Riphean oil and gas bearing complex. The most likely zones of spatial localization for them should be the arch and subarch sectors of pre-Paleozoic and Paleozoic uplifts within which productive horizons were moved under the surface of discontinuity by Precambrian erosion.

It is most likely that lithologic non-anticlinal pools (of the type of the Parfenovskiy pool at the Markovskiy deposit) will be found in the basal horizons of the Vendian-Lower Cambrian terrigenous complex in zones of pre-Paleozoic erosion. The primary prospects should be associated with sectors of consedimentation submergences which are most favorable for the formation of basal sandstone pockets.

FOOTNOTES

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FUELS

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OIL, GAS BEARING SEDIMENTS OF SOUTHERN SIBERIAN PLATFORM

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 1, Jan 80 pp 5-9

[Article by A. S. Antsiferov, VostSibNIGGIMS: "Gas and Chemical Zonality of the Layer Waters of Oil and Gas Beds in the Southern Part of the Siberian Platform"]

[Text] In the southern part of the Siberian platform, as is commonly known, the Lower Cambrian and Precambrian beds contain oil and gas. They are subdivided into two hydrogeological units: the subsalt unit (Ushakovskiy and Motskiy suites and the lower part of the Usol'sk suite inclusively to the Osinskiy layer) and the salt-bearing unit (the Usol'sk suite above the Osinskiy layer and all the overlying salt-bearing Lower Cambrian beds to the Angara and Litvintsevskiy suites inclusively). In both units water-bearing complexes and productive layer-reservoirs are identified, separated by confining strata of rock salt, varieties of clay, dense dolomite-anhydrites, and other rocks.

The subsalt hydrogeological unit is most promising for oil and gas, and within it the best prospect is the Ushakovskiy-Lower Motskiy terrigenous hydrogeological complex (terrigenous beds lying directly on the basement of the platform) where several oil-gas-water bearing layers of sandstones and aleurolites have been identified (Parfenovskiy, Botuobinskiy, Vilyuchanskiy, and others). Most of the oil and gas deposits discovered there are also related to them (the Markovskiy, Yaraktinskiy, Middle Botuobinskiy, Upper Vilyuchanskiy, Bratsk, Shamanovskiy, and other deposits).

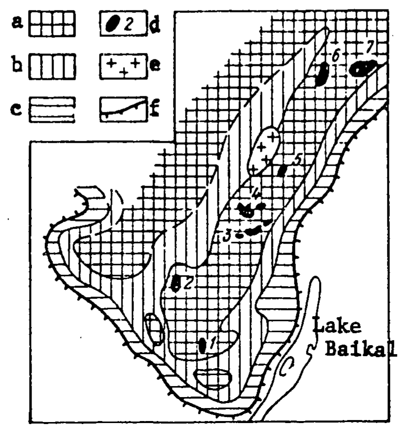
The hydrogeological characteristics of these beds have not been thoroughly studied on a regional scale yet, but available findings already permit us to outline a fairly distinct zonality based on both the composition of water-dissolved gases and other hydrogeological indexes.

There are basically three types of water-dissolved gases in the subsalt terrigenous complex in the southern part of the platform [2]: methane (more than 75 percent hydrocarbons), nitrogen-methane (25-50 percent nitrogen, more than 50 percent hydrocarbons), and nitrogen (more than 75 percent nitrogen). Owing to the small quantity of "acidic" gases (CO_2 + H_2S) there are as yet no grounds to identify other types. High content of other types is observed only in the waters of overlying sulfate-carbonate rocks of the Upper Motskiy-Osinskiy complex and the salt-bearing hydrogeological unit.

The zonality of the composition of water-dissolved gases in subsalt terrigenous beds of the Ushakovskiy-Lower Motskiy complex is shown in Figure 1 below. A zone of gases that are primarily nitrogen type extends in a narrow strip along the margins of the platform (along its boundary with the Sayan-Baikal folded mountain ring). The level of gas saturation of layer waters there is usually not greater than 30-50 cubic centimeters per liter and elasticity (saturation pressure) is also low, no more than 1-2 megapascal. In well No 2 at the Bol'sherazvodninskiy site, for example, the gas saturation of the water is 20 cubic centimeters per liter, and the dissolved gas contains 90.02 percent nitrogen, 8.05 percent acid gases, and just one percent methane. Eighty percent of the nitrogen comes from the air. The zone of nitrogen-methane gases directly adjoins the zone of nitrogen gases and also stretches in a narrow band, generally following the contours of the edge of the platform. In addition, this zone cuts deeply into the central part of the basin as a band along the articulation of the Sayan-Yenisey and Tunguska syneclises with the Angara-Lena bench and the Nepsko-Botuobinskiy anteclise. The gas saturation of layer waters there reaches 200-700 cubic centimeters per liter with a content of 50-70 percent methane, up to 10-12 percent heavy hydrocarbons, 25-47 percent nitrogen, and less than two percent acid gases. The total partial elasticity of gases reaches eight and sometimes 10 megapascal or higher. The entire remaining (interior) part of the basin is the zone of distribution of methane gases (with the exception of the above-mentioned strip along the eastern boundary of Sayan-Yenisey and Tunguska syneclises).

It should be observed that a zone of methane gases has been identified in the northwestern part of this region (in the Sayan-Yenisey and Tunguska syneclises) primarily from general geological assumptions. At the present time it has been confirmed by a small number of wells drilled at the Kumyumbinskiy deposit and at the Vanavara and certain other remote sites. In the central part of the Angara-Lena bench and eastern slopes of the Nepsko-Botuobinskiy anteclise, however, the zone of methane gases has been mapped with certainty on the basis of many boreholes from the Sayans to the Botubinskiy gas field inclusively. The gas saturation of layer waters there exceeds 500-700 cubic

Figure 1. Diagram of the Composition of Water-Dissolved Gases of Terrigenous Beds of the Ushakovskiy-Lower Motskiy Complex of the Southern Siberian Platform.



Key: Zones of Distribution of Gases:
- (a) Methane Type (More than 75 Percent Hydrocarbon by Weight);
- (b) Nitrogen-Methane (50-75 Percent Hydrocarbon, 25-50 Percent N_2;
- (c) Nitrogen (More than 75 Percent N_2);
- (d) Deposits in Terrigenous Beds:
  - (1) Shamanovskiy;
  - (2) Bratsk;
  - (3) Group of Pools in Markovskiy Region;
  - (4) Yaraktinskiy and Ayanskiy;
  - (5) Upper Chona;
  - (6) Middle Botuobinskiy;
  - (7) Upper Vilyuchanskiy;
- (e) Top of Nepskiy Arch Where Terrigenous Beds are Lacking;
- (f) Southern Boundary of Siberian Platform.

Note: Types of gases are indicated according to [2].

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centimeters per liter everywhere, and the dissolved gases are all methane in composition (75-90 percent methane, 5-15 percent heavy hydrocarbons, 3-6 percent nitrogen, and less than one percent acid gases). The elasticity of the gases generally exceeds 10 megapascal.

It is distinctive that the gas saturation and content of methane and heavy hydrocarbons here increase consistently toward the center of the Angara-Lena bench and the eastern slopes of the Nepsko-Botuobinskiy anteclise, reaching a maximum near the oil and gas pools. For example, at well No 5 near the edge of the Yaraktinskiy pool the gas saturation of the water (brine) reaches 1,392 cubic centimeters per liter with a gas elasticity of 26.5 megapascal, which is equal to layer pressure (that is, the gas saturation factor P_{gas} P_{water} = 1). In all the deposits identified here free gases are of the methane type with a high content of heavy hydrocarbons and gas condensate. A particularly high level of gas condensate is recorded in regions of the Nepsko-Botuobinskiy anteclise where many pools have industrially important oil fringes (Yaraktinskiy Middle Botuobinskiy, and others).

This kind of gas zonality cannot be satisfactorily explained by the lithology of the encompassing terrigenous beds (their content here is fairly constant), the depth of the productive horizons (which ranges from 1,500 to 4,000 meters in the methane gas zone), the conditions of oil and gas formation, or the degree of metamorphism of the dispersed organic matter of the Ushakovskiy-Lower Motskiy oil and gas mother rock because, according to paleoreconstructions, they were never submerged in the Nepskiy arch to the depths necessary for the principal phase of gas formation. Moreover, in the Baikal and Sayan paleoforedeeps where such paleodepths did occur in the path, methane gases are not recorded today; by contrast nitrogen-methane and nitrogen gases are found there. Therefore, we link the modern zonality of water-dissolved gases chiefly with the ancient and modern hydrodynamic conditions of the water-bearing complexes.

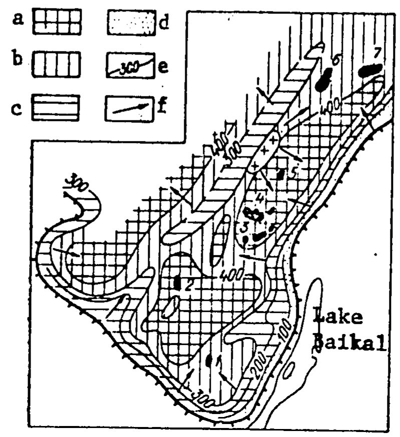
Paleohydrodynamic reconstructions of the terrigenous complex show that throughout all geological history from the Vendian until the present day the central sectors of the Angara-Lena bench and the Nepskiy and Mirninskiy arches of the Nepsko-Botuobinskiy anteclise (that is, the territory of the modern methane gas zone) were stable paleopiezominimums and served as large regional zones of discharge to which waters carrying significant amounts of hydrocarbons gravitated. For example, in the elision stage (to Silurian inclusively) sediment-derived water squeezed out of the Baikal paleoforedeep moved toward these discharge zones in the east and water from submerged sectors of the Sayan-Yenisey and Tunguska syneclises did so in the west. In the infiltration stage, which began to develop as the result of general uplifting of the platform in the late Silurian and continues to the present day, the territories with methane-type gases have also been regional discharge zones and are characterized by minimum calculated layer water pressures. The piezometric lines of the calculated levels with low absolute figures (+100 meters in the southern part of the amphitheater outline the central part of the Angara-Lena bench; pressures are even lower in the Nepsko-Botuobinskiy anteclise and decrease regularly toward the northeast, reaching a minimum in the Botuobinskiy gas field. Maximum pressures are recorded on the margins of the platform, where they reach 500-600 meters above sea-level [11].

The movement of layer waters in subsalt terrigenous beds today goes from the basic recharge zones, which are located on the margins of the platform and have nitrogen-type dissolved gases (these beds have come out on the surface or are fed by meteoric water along the disjunctive faults of the marginal suture of the platform) to the interior sectors of the basin where the gases are first nitrogen-methane and then typical methane type. In addition, a movement of water is also observed from the tectonically weakened zone of articulation of the Angara-Lenin bench and Nepsko-Botuobinskiy anteclise with the Sayan-Yenisey and Tunguska syneclises. At this point there is a "supplementary feeding" of the terrigenous complex within the platform by diluted (freshened) brines leached from overlying salt-bearing strata. The gases here are nitrogen-methane type, in a general setting of methane gases.

The zonality of mineralization and composition of layer waters (see Figure 2 below) is basically analogous to the gas zonality and also reflects the modern hydrodynamic regime of the terrigenous beds; the lines of equal mineralization follow the contours of the piezometric lines of calculated pressures almost in detail. As one moves further from the primary recharge zone (from the margins of the platform) the total mineralization of layer waters increases quickly from fresh and subsaline to chloride sodic leached brines with mineralization of up to 300 grams per liter. The entire interior part of the basin, with the exception of the zone of supplementary recharge on the boundary with the Sayan-Yenissey and Tunguska syneclises, is characterized by strongly mineralized chloride calcium and magnesium- calcium brine with mineralization of greater then 300 grams per liter, and in the central part of the Angara-Lena bench, the eastern slopes of the Nepsko-Botuobinskiy anticlise, and on the sides of the syneclises (that is in the methane gas zone) mineralization exceeds 400 grams per liter.

Therefore, the gas zonality and geochemical zonality of the layer waters of the subsalt terrigenous complex have a similar pattern of occurrence here (regular alternation of zones from the margin of the platform to the interior of the basin) and they are both primarily the result of the hydrodynamic situation. The zones of maximum gas saturation with methane-type dissolved gases coincide with the zones of chloride calcium brines of maximum mineralization and metamorphism (highly complicated water exchange regime, close to stagnant); the zones of nitrogen-methane gases coincide with the zones of strong chloride calcium and sodium-calcium brines with a lower degree of metamorphism (difficult water exchange regime); finally, the zones of nitrogen gases are confined to zones of fresh water and weak chloride

Figure 2. Diagram of Mineralization and Salt Content of Layer Waters of Terrigenous Beds of Ushakovskiy-Lower Motskiy Complex of Southern Siberian Platform.



Key: Zones of Development:

(a) Strongly Metamorphised Brines of Chloride Calcium and Magnesium-Calcium Composition with Mineralization of Greater then 400 Grams per Liter;
(b) Same with Mineralization of 300-400 Grams per Liter;
(c) Metamorphised Brines of Chloride Sodium-Calcium Compositions and Strong Leached Brines of Sodic Composition with Mineralization of 100-300 Grams per Liter;
(d) Weak Leached Brines of Chloride Sodic Composition with Mineralization of Less than 100 Grams per Liter and Saline and Fresh Waters;
(e) Lines of Equal Mineralization, Grams per Liter;
(f) Direction of Movement of Layer Waters.

Note: Remaining symbols explained in Figure 1.

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sodic leached brines, that is, to zones of infiltration and vigorous water exchange.

It is of practical interest that oil-gas pools have been identified in subsalt terrigenous beds in the southern part of the platform only in the zone of methane-type gases, which stretches from the approaches to the Sayans to the Botuobinskiy gas region. This zone has favorable conditions not only for the formation of pools (stable paleopiezominimums were located there in the past), but also for their preservation. Minimum calculated pressures (compared to surrounding areas) are recorded in this zone and the regime of water exchange is highly retarded, close to stagnant. According to calculations, the rate of movement of the brine is measured in tenths and hundredths of a centimeter a year. Mineralization of the brines is close to the maximum possible, reaching 400-450 grams per liter. They have a chloride calcium and calcium-magnesium composition (chlorides of calcium and magnesium reach a total of 80-90 percent equivalent and more), and the degree of metamorphism is also maximal (Na/Cl < 0.4, dropping to 0.2-0.04). The brines contain a great deal of bromine (Cl/Br < 50, decreasing to 40-35) and few sulfates (the coefficient 100 r SO / Cl < 0.08. Brines containing no sulfate also occur. It is clear from this that the zone of methane gases stretching across the central part of the Angara-Lena bench and eastern half of the Nepsko-Botuobinskiy anticlise (from the Sayan foothills to the Botuobinskiy gas region inclusively) should be viewed as the most promising territory to search for new oil and gas pools in the southern part of the Siberian platform (see Figure 1 above). The slopes of the Sayan-Yenisey and Tunguska syneclises are also very promising, but the terrigenous deposits of the Motskiy and Ushakovskiy suites (and their analogs) lie at great depth there (more than 4,000 meters).

In conclusion it should be observed that the regional patterns of gas and chemical zonality of layer waters in the subsalt terrigenous complex that have been presented are basically repeated in the overlying upper Motskiy-Osinskiy hydrogeological complex, where the Preobrazhenskiy, Osinskiy, and other layers of carbonate rocks are productive (interstice-joint and cavern types of reservoirs). The only differences are that the zone of methane gases in the Upper Motskiy-Osinskiy complex is broader in area, the dissolved and free gases usually contain hydrogen sulfide and carbon dioxide, and the mineralization of the brines is even higher, reaching 500-600 grams per liter. The regional paleohydrogeological patterns in them also coincide in large part because the development of the basin followed a plan inherited from the Vendian. Therefore, the chief conclusions on patterns of gas and hydrochemical zonality of layer waters and the high promise of the petroleum and gas zone of methane gases which were reached for the terrigenous Ushakovskiy-Upper Motskiy complex may also be applied to the Upper Motskiy-Osinskiy complex adjacent to it. This complex is especially promising at the peaks of the Nepskiy, Mirninskiy, and other large arched uplifts where terrigenous beds are absent or greatly reduced in thickness, while the carbonate rocks of the Upper Motskiy subsuite and Osinskiy layer have greater jointing, which increases permeability and the capacity of a jointed reservoir. Moreover, at the peaks of these uplifts rock salt beds between the Osinskiy and the roof of the Motskiy suite decrease abruptly in thickness, and in the Mirninskiy arch they are completely gone from the cross-section. This promoted vertical migration of hydrocarbons and their accumulation in the Osinskiy horizon, which is in this case a convenient reservoir regionally overlapped by a thick stratum of salt beds of the Usol'sk, Bel'skiy, and other overlying suites of the Lower Cambrian. Oil and gas pools in carbonate layers of the Upper Motskiy-Osinskiy complex have already been discovered at the Middle Botuobinskiy, Preobrazhneskiy, Markovskiy, Atovskiy, and several other sites; all of them are located within the methane gas zone.

These patterns of hydrogeological, gas, and chemical zonality of layer waters are important for predicting oil and gas prospects in the particular region, and for this reason they need continued study in greater detail.

FOOTNOTES

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FUELS

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PETROLEUM PROSPECTS OF CASPIAN DEPRESSION

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 12, Dec 79 pp 1-7

[Article by Z. Ye. Bulekbayev, Yu. A. Ivanov, V. P. Smetanina, B. S. Zasybayev and L. P. Traynin]

[Text] A great deal of exploratory prospecting has been concentrated in the eastern part of the Caspian depression. The success of this work depends in large measure on proper choice of the most promising sites.

In this territory, regions with established industrial oil and gas show of subsalt deposits are confined to extensive ridges of the substructure: the Yenbek (Temir) and Zharkamys ridges. Within the limits of their tips the surface of the substructure lies at depths of 7-7.5 km; on the -8 km isohypse the dimensions of the ridges are 225 x 75 and 180 x 60 km with amplitudes of more than 1.5 km.

Corresponding to the ridges of the substructure in the lower strata of the subsalt complex (with respect to reflecting stratum P_3) are extensive upheavals (Fig. 1). It is assumed that the structure of stratum P_3 is characterized by Devonian formations that have not yet been tapped by boreholes. Judging from the values of formational velocities ($v_f = 4500$ m/s according to data of the common depth point method), terrigenous rocks lie below the P_3 stratum. Their thickness varies from 1500-2000 m on submerged ridges to 500-1000 m in crestal sections.

On the eastern slope of the Zharkamys ridge, against a background of regional submersions to the east from 7200-8000 m, and toward the southwest from 6600 to 8400 m, we find the Tobusken arch extending from north to south to a distance of more than 70 km. The axial part of the arch is complicated by the Tobusken, Tortkol' and other upheavals.

The relief of the Yenbek upheaval is shown best by reflecting stratum P_2, which is identified with the roof of the Upper Carboniferous carbonate formations (on the -5 km isohypse its dimensions are 75 x 25 km with an amplitude of more than 1000 m). The central section of the upheaval is

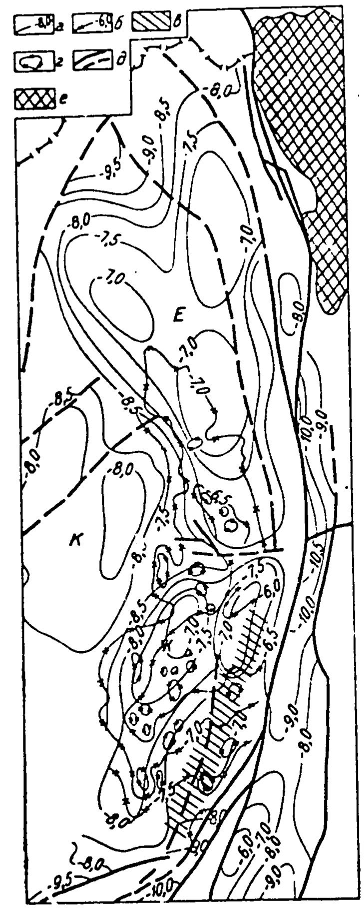

Fig. 1. Structural map of the surface of the substructure of the Yenbek-Zharkamys region: *а*--isohypses of the surface of the substructure, km; *б*--isohypses for stratum P_3; *в*--Tobusken arch; *г*--local subsalt upheavals; *д*--tectonic disturbances; *е*--Uraltau zone; *Е*--Yenbek ridge; *Ж*--Zharkamys ridge; *К*--Kzyldzhar ridge

bounded c ·e west by the zone of loss of correlati. of stratum P_2. To the east, stratum P_2 sinks toward the Ostansuk downwarp to a depth of 6 km. A number of local structures show up on stratum P_2 within the limits of the upheaval: Akkum, Akkuduk, Baktygarin and others. These upheavals can be traced from the roof (stratum P_1) to the lowest beds of the subsalt complex (stratum P_3). The depth of occurrence of the surface of carbonates within the limits of local upheavals is 4.3-4.8 km, and the roof of the subsalt formations occurs at 3.5-4.4 km.

The Zharkamys ridge has a more complicated structure with respect to Carboniferous formations. The carbonate formations in the subsalt cross section occur only in the eastern part -- the Tortkol'-Zhanazhol' zone. Reflecting stratum P_2 is associated with the surface of carbonates in the north part. This stratum delineates a large arch structure that joins the Zhanazhol', Priemben and Kungur upheavals (on the -3 km isohypse its dimensions are 17 x 5 km with amplitude up to 400 m). Further south on stratum P_1^1, which is apparently likewise confined to the surface of carbonates, we find the Sinel'kovskaya, Chudovskaya and other structures; the roof of the Upper Carboniferous carbonate formations here occurs at depths of 2800-2900 m. Further to the south, on the fields of Tuskum, Vostochnaya, Dal'nyaya, Tortkol' and Tobusken the nature of the surface of occurrence of carbonates is not clear. To judge from drilling data, it coincides with stratum P_1 on the East Tortkol' field.

The structure of the lower part of the carbonate complex in the Tortkol'-Zhanazhol' zone is characterized by the conditions of occurrence of stratum P_2^1 (in well No 1 at East Tortkol' the underside of the carbonates is situated on an absolute control point depth of -3200 m, while the vertical control point of stratum P_2^1 is at -2900 m). This stratum shows a monoclinal fold that sinks toward the west and is bounded on the east by a tectonic disturbance.

In the western part of the Zharkamys ridge, according to data of seismic prospecting and drilling of North Kindysay well No 2, the Upper Carboniferous carbonate deposits are replaced by terrigenous formations. The conditions of occurrence of these formations are characterized here by stratum P_2^1. From this stratum, at a depth of 5-5.6 km, we find the Kozdysay-Karatyube terrace, complicated by local structures. Within the limits of this terrace, the thickness of the formations between strata P_1 and P_2^1 indicates a large arch extending more than 100 km. Local upheavals of Akzhar, Kursay and others are confined to the west end of this arch.

The Yenbek and Zharkamys ridges of the substructure do not show up on the surface of the subsalt complex (stratum P_1): the subsalt bed undergoes monoclinal submersion from east to west, and is complicated by structural terraces and local folds. The lack of correspondence of the structural plans on the roof of subsalt formations to lower-lying strata does not extend to local structures. Stratum P_1 shows these local structures as chains; on deeper levels (Carboniferous and Devonian) they also correspond to local upheavals with dimensions and amplitudes that increase with depth. On the described territory a total of about fifty local upheavals have been discovered, represented by brachyanticlinal structures with dimensions of 5-15 x 2-7 km with amplitudes usually of 100-200 m, and less frequently up to 300 m.

The nature of thickness variation of the Paleozoic complex as shown by seismic data (between strata F-P_3, P_3-P_2, P_3-P_2^1, as well as drilling results in the Kenkiyak and Aransay fields, which establish precipitation from the cross section of formations of the Upper and most of the Middle Carboniferous, give evidence of ancient origins, no more recent than the Devonian, and of an inherited development of the Yenbek and Zharkamys upheavals at least predating the Early Permian Epoch.

At the present time, at least two complexes with oil and gas show have been found in the cross section of subsalt formations of the Yenbek-Zharkamys zone: terrigenous Lower Permian and carbonate Upper Carboniferous.

Terrigenous Asselarian-Artinskian rocks 600-1200 m thick are made up of argillites, aleurolites and sandstones with seams of gritstones and conglomerates. The Molasse nature of the stratum is responsible for its considerable facies variability due to the occurrence of debris cones of coarsely fragmented material in the eastern part of the territory. To the west, the Asselarian-Artinskian formations acquire a predominantly argillaceous composition with inclusion of sandstone-aleurolite members. The Kenkiyak, Bozoba and Karatyube petroleum deposits show up in the Lower Permian terrigenous complex. The first two are situated in the southern part of the Yenbek ridge. The productive strata of these deposits are characterized by comparatively low collector properties and are not spatially extensive, which in combination with anomalously high formational pressure makes it difficult to bring them under exploitation.

The carbonate Upper Carboniferous formations in the eastern part of the Caspian depression are limited in extent. The western boundary of development of carbonate deposits is reliably indicated by seismic prospecting based on the correlational method of wave refraction and the common depth point method on the Yenbek upheaval, where it is associated with a regional zone of loss of correlation of reflecting stratum P_2, passing along the meridian of Kenkiyak-Yenbek structures, and with loss of signal from high-velocity refracting stratum d_4^{oc}. To the north, the region of development of carbonates can be traced to the latitude of the North Akkuduk structure. It stretches to the south along the eastern slope of the Zharkamys ridge of the substructure west of the Zhanazhol, Tuskum and Tobusken structures, and extends to the South Emben upheaval, where carbonates have been tapped on the fields of Sarykum (wells 1 and 2) and Turesay (well No 3).

The carbonate Upper Carboniferous stratum is tapped by isolated wells at the present time. Occurring in the Zhanazhol fields (wells No 1, 5, 5) under terrigenous Asselarian-Sakmarian rocks 350-550 m thick are a sulfate-carbonate member of the Upper Carboniferous (130-240 m), carbonates of the Middle Carboniferous (Upper Moscovian substage, 294 m), which are completely traversed by well No 5 in the interval of 3119-3508 meters. The carbonate stratum is represented by biochemogenic varieties of limestones made up of chemogenic calcite (50-85%) and organogenic residues (Bryozoa, Ostracoda, brachiopods and so on, 25%). Another cross section has been tapped on the East Tortkol' field: directly under the Kungurian Stage of the Lower Permian are rocks of the carbonate Middle Carboniferous 421 m thick, and lower still are limestones of the Visean Stage (748 m) with underlying terrigenous, chiefly argillaceous, formations of the Lower Visean with a tapped thickness of 690 m. Within the limits of the Yenbek arch, only the upper part of the carbonate stratum has been tapped, with Bashkirian formations occurring in the roof. Upper Bashkirian (Cheremshanian) have been brought up in well No 1 of the Aransay field in the interval of 4832-4868 m. Occurring beneath the Lower Permian rocks in Kenkiyak well No 89 are Lower Bashkirian (Krasnopolianian) and Lower Carboniferous limestones with a tapped thickness of 134 m, organogenic-detrital, sometimes with a brecciated structure. To the east of the Yenbek upheaval in Alibekmola well No 13, a terrigenous-carbonate cross section of Middle and Upper Carboniferous formations has been tapped, represented by alternation of limestone and sandstone-argillaceous members more than 1000 m thick.

Thus the thickness and stratigraphic volume of the carbonate complex varies considerably over the area.

In the west section of the Yenbek ridge and the axial part of the Zharkamys ridge, i. e. in the zone where carbonate strata are replaced with terrigenous formations, apparently characterized by comparatively deep-sea conditions of sedimentation, we can expect the development of facies that have a reef origin. The convergence of cophasal axes on the epochal

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cross sections on certain stratigraphic levels shows the possibility of structures of reef origin in local upheavals of the carbonate shelf of the Tortkol'-Zhanazhol region. Individual profiles plotted on the South Tuskum structure show a "seismic wedge" between strata P_1^1 and P_2^1, which is one of the indications of the possibility of a structure of reef origin here.

The oil and gas show of the Carboniferous carbonate complex has been proved: on the Zhanazhol field an openface check of limestones of the Moscovian Stage in well No 4 (interval of 2767-2894 m) gave an inflow of petroleum and gas (with a 13.5 mm pipe the daily yield reached 215.2 cu. m of petroleum and 176,140 cu. m of gas at a formational pressure of 29.1 MPa). The petroleum had a density of 0.817 g/cc, paraffin-free, sulfur content 1.03%. Gas composition, %: CH_4--83, heavy hydrocarbons--9.5, N_2--2.2, CO_2--0.62 and H_2S--1.28. In Zhanazhol well No 5 in a check by a stratum analyzer during drilling, petroleum flows with dissolved gas were obtained from carbonates of the Upper Carboniferous (2790-2819 m with yield of 280 cu. m/day) and from rocks of the Middle Carboniferous (2819-2842 m, 300 cu. m/day and 2848-2901 m, 277 cu. m/day). According to data of wells No 4 and 5 this is apparently a massive planktonic formation. The effective thickness of the productive stratum is 132 m, and the collector is cavernous-porous limestone with effective porosity of up to 12% according to preliminary data. Further to the south, on the East Tortkol' fields (well No 1), signs of petroleum and gas have been found in limestones of the Middle and Lower Carboniferous (the well has not been assayed). Petroleum and gas shows have been noted in other wells that tap formations of the carbonate complex (Alibekmola 13, Kenkiyak 89, Aransay 1). Thus the carbonate formations of the Carboniferous in the eastern part of the Caspian depression constitute a new area for exploratory prospecting.

If consideration is taken of the quite probable pre-Permian erosion, the upper part of the carbonate complex may be of great interest; under the predominantly argillaceous Lower Permian cover the carbonate collectors may contain hydrocarbon traps.

The data given here on the geological structure and on the petroleum and gas show of the Yenbek and Zharkamys ridges of the substructure show that there is a good outlook for zones of petroleum and gas accumulation associated with these structures. Within their limits are four oil and gas bearing regions: I--Tortkol'-Zhanazhol; II--Kenkiyak-Akkuduk; III--Kozdysay-Karatyube-Karaoba; IV--Ostansuk (Fig. 2).

The necessity for immediate acquisition of the Tortkol'-Zhanazhol region is dictated by the development there of a carbonate Carboniferous stratum up to 1200 m thick with proved industrial petroleum and gas show occuring at depths of 2100-2800 m, and by confinement of the region to the eastern part of the extensive Zharkamys anticline, complicated here by the large Tobusken arch structure on the lower strata of the sheath (stratum P_3).

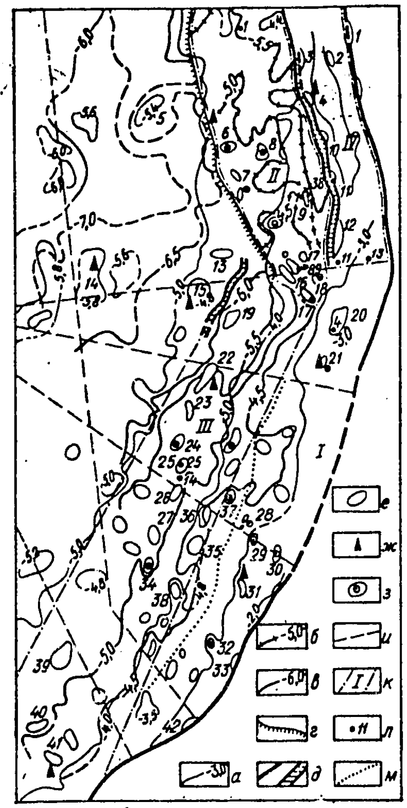

Fig. 2. Map of the petroleum geology zoning of the Yenbek-Zharkamys region of petroleum and gas accumulation: Isohypses: *а*--of the surface of subsalt formations (stratum P_1); *б*--roof of the carbonate Carboniferous (stratum P_2); *в*--of stratum P_2^1 in the terrigenous Carboniferous; *г*--line of the loss of correlation of reflecting strata; *д*--tectonic disturbances; *е*--local subsalt upheavals; *ж*--recommended parametric holes; *з*--areas recommended for exploratory drilling; *и*--recommended regional profiles of the common depth point method; *к*--regions with different degrees of promise: I--Tortkol'-Zhanazhol; II--Kenkiyak-Akkuduk; III--Kozdysay-Karatyube-Karaoba; IV--Ostansuk; *л*--deep holes that have been drilled; *м*--proposed western boundary of the occurrence of carbonate formations within the limits of the Zharkamys ridge. Structures: 1--Zharyk; 2--Dzhurun; 3--Baydzharyk; 4--North Ostansuk; 5--Subarkuduk; 6--Akkuduk; 7--Baktygaryn; 8--Akkum; 9--Aransay; 10--Lakkaragan; 11--Ostansuk; 12--Taldyshoki; 13--Krykkuduk; 14--Karaulkel'dy; 15--Itasay; 16--Kenkiyak; 17--North Urikhtau; 18--South Motuk; 19--Kozdysay; 20--Zhanazhol; 21--Sinel'nikovskaya; 22--Tasshiy; 23--Akzhar; 24--Kursay; 25--Karatyube; 26--North Kindysay; 28--Tuskum; 29--South Tuskum; 30--Dal'nyaya; 31--East Tobusken; 32--Tortkol'; 33--East Tortkol'; 34--Chirkala; 35--Teleumbet; 36--Ayshuak; 37--Shotykol'; 38--Borzher; 39--Kuyantakyr; 40--Al'muratkonyr; 41--Taskabak; 42--Karate

According to the results of assaying of the wells, the carbonate collectors are characterized by rather high capacitive and filtration properties. Within the limits of the territory, 17 local continuous rises have been established, including the Zhanazhol, Kungur and Priemba rises, which may form a single positive structure measuring 17 x 5 km with an amplitude of 400 m (according to the -3 km isohypse). In the eastern part of the territory adjacent to the Ashchisay regional break we can expect extensive development of non-anticlinal traps, while in the west, on the section of facies transition of carbonates to terrigenous varieties, we can predict the occurrence of traps of reef origin. In places on this territory the Lower Permian terrigenous formations may have a coarsely fragmented composition with favorable collector properties. The terrigenous rocks of the Lower Carboniferous-Devonian, as pointed out above, are characterized by favorable structural conditions. The roof of the terrigenous Lower Carboniferous-Devonian complex occurs at a fairly shallow depth (3100-3300 m). Within the limits of the territory a salt-bearing cover extends everywhere, and on most of the region it is Lower Permian argillaceous. Thus the outlook for oil and gas show on this territory is associated not only with carbonate formations, but also with terrigenous Lower Permian and Lower Carboniferous-Devonian formations.

The outlook for oil and gas show of the Kenkiyak-Akkuduk region is determined by the discovery of the Kendiyak and Bozoba deposits in Lower Permian rocks, and by the occurrence on this territory of a carbonate complex with proved oil and gas show (Kenkiyak well No 107 and Aransay well No 1) at a depth that is accessible for drilling (4.5-4.7 km). This region is situated within the limits of the large (75 x 25 km) high-amplitude (more than 1000 m) arch-like Yenbek upheaval over the roof of carbonate formations. Despite inadequate seismic studies, 12 local upheavals have been found within its limits, their dimensions and amplitude increasing with depth. In the submerged parts of the Yenbek rise we can expect the development of non-anticlinal traps, while traps of reef origins can be expected on the west slope.

In the Kozdysay-Karatyube-Karaoba region the industrial oil and gas show of the Lower Permian complex has been proved by the discovery of the Karatyube deposit. However, the prospects for oil and gas show of this region are decreasing in connection with deterioration of collector properties and the deeper occurrence (down to 4100 m) of Lower Permian productive strata. The carbonate formations of the Carboniferous within this territory, judging from seismic data, are replaced by terrigenous formations in which we cannot expect satisfactory collectors. In this territory, 19 local upheavals have been discovered, most of which have been made ready for deep drilling.

The Ostansuk petroleum and gas region is characterized by shallow occurrence (2.2-3.5 km) of Lower Permian terrigenous formations. The petroleum and gas shows and considerable thicknesses of these rocks (about 1200 m) have been established by drilling of Ostansuk well No 38. On the roof of the subsalt bed here, eight anticlinal upheavals have been found with dimensions of up to 10-15 x 1.5-2.5 km. The western, most extensively studied chain of structures consists of the Taldyshoki, Ostansuk and other folds; the Dzhurun, Zharyk and other upheavals show up in the eastern part. The border zones of the downwarp are promising for finding non-anticlinal traps. The occurrence of a Carboniferous carbonate complex has been established here at a depth of 4.8-5.2 km.

Future exploratory prospecting for petroleum and gas in the eastern part of the Caspian depression should be aimed primarily at the most rapid acquisition of the carbonate Carboniferous formation. In the coming years research and prospecting work will be concentrated in the Tortkol'-Zhanazhol region and will be aimed at acquisition of productive carbonate formations and further investigation of terrigenous Lower Permian, Lower Carboniferous and Devonian complexes. During the 11-th Five-Year Plan it is advisable to continue exploartory prospecting in the central part of the territory as well on structures of Tuskum, South Tuskum, Dal'nyaya, Vostochnaya and so on. The depths of exploratory wells into the carbonate Carboniferous and Lower Permian terrigenous complexes do not exceed 3.5-4 km. Wells up to 5.5 km deep will be needed in studying the Lower Carboniferous-Devonian complex.

The task of seismic studies and exploratory drilling is investigation of the eastern part of this region for the purpose of finding tectonically shielded and non-anticlinal traps. The common depth point method should be used to study the southern continuation of the Tortkol'-Zhanazhol zone of development of carbonates from the Karate structure to Sarykum. On the western part of the region it is recommended that an investigation be made of the details of facies replacement of carbonate by terrigenous formations in order to find bodies of reef origin.

In the Kenkiyak-Akkuduk territory confined to the Yenbek upheaval, the acquisition of the Lower Permian complex on the Kenkiyak and Bozoba deposits is tied up to a great extent with resolution of the technological problems of well drivage and assaying. Here it is recommended that drilling be continued on the Baktygaryn and Aransay fields, and that the South Mortuk and North Urikhtau structures be brought under drilling for the purpose of further investigation of the Lower Permian terrigenous complex, and evaluation of the outlook for oil and gas show of the carbonate Carboniferous complex. Drilling to the Lower Permian complex will require a well depth of up to 4.5 km, while the depth to the carbonate complex will be up to 5.5 km. Seismic studies should be done to get a better idea of the structure of the crestal part and the periclinal zones of the Yenbek Paleozoic upheaval, the details of local structures, and the occurrence of the carbonate complex toward the north.

In the next most promising region of Kozdysay-Karatyube-Karaoba, exploratory drilling of the structures of Shotykol' and Tereshkovskaya will give a final evaluation of the Lower Permian and Carboniferous terrigenous complexes, and in case of positive results the drilling will be continued on the upheavals of Ayshuak, Kursay, Chirkala, Karaoba and elsewhere. The wells in this territory are 5-5.5 km deep. The goal of geophysical research is to find the details of local upheavals and to study the western and southern submersions of the Sharkamys arch.

In the Ostansuk region it is suggested that seismic research be done in the 10-th and 11-th Five-Year-Plan to find and study local upheavals, and that individual parametric wells be sunk to the Lower Permian terrigenous complex (depth 3-4 km) and to the Carboniferous carbonate complex (depth 5.5 km).

The main volume of regional work in the next 6-7 years should be concentrated within the limits of the Yenbek and Zharkamys zones of petroleum and gas accumulation, chiefly to study the pre-Permian complex. Exploratory drilling will mainly cover depths to 5 km, and therefore the depth of parametric drilling should be increased to 5.5-6.5 km. It is recommended that parametric wells each 5.5 km deep be located on the fields of Akkuduk, Sinel'nikovskaya, Tasshiy, Taskabak, East Tobusken and North Ostansuk, in the crestal section and the sunken sections of the Yenbek and Zharkamys ridges. In new territories on large subsalt upheavals in the 11-th Five-Year Plan, drilling can be recommended on wells confirmed by regional studies in Kolandy and Karaulkel'dy, and also in Itasay (the depths of these wells to be 6-6.5 km). Regional seismic studies should resolve the question of the structure of the Yenbek-Zharkamys zone with respect to intra-subsalt strata, and the position of this zone in the general tectonic structure of the eastern border of the Caspian depression.

Implementation of the proposed measures will improve the efficacy of exploratory prospecting for petroleum and gas in the eastern part of the Caspian depression, and will help to meet the quotas of the 10-th and 11-th Five-Year Plans for increasing the reserves of petroleum and gas.

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OIL AND GAS PROSPECTING IN KALMYK ASSR, ASTRAKHAN

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 12, Dec 79 pp 7-13

[Article by A. V. Ovcharenko, N. V. Mizinov, A. Ya. Mordovin, D. L. Fedorov and O. G. Brazhnikov]

[Text] Exploratory prospecting for petroleum and gas has been going on in the Kalmyk territory and Astrakhanian Povolzh'ye for a long time. In the late fifties and early sixties several gas and oil deposits were discovered with small and moderate reserves, now being used for gas supply to Elista and Astrakhan'.

During the Ninth Five-Year Plan, after shifting the main volumes of geological prospecting from the southern slope of the Karpinsk ledge to the southwestern regions of the Caspian depression, there was a considerable improvement in the efficacy of the research being done, and the first gas flows were obtained from subsalt formations on the Astrakhan' deposit.

The high prospects of the Kalmyk territory and Astrakhanian Povolzh'ye have been scientifically substantiated in some detail [Ref. 1-3]. This region includes the southwestern part of the Caspian depression and the Karpinsk ridge (Fig. 1). The principal direction for exploratory prospecting was chosen on the basis of an assumed close relation between tectonic forms favorable for petroleum and gas accumulation and possibly productive complexes.

In the Caspian depression, the main areas for petroleum and gas searches are subsalt formations, secondary areas are supersalt formations, and also Mesozoic formations (within the limits of the Karpinsk ledge).

The primary objects that have been set apart on the Caspian depression are the Astrakhan anticline, the Karakul' arch and subsalt structures of the Karasal' monoclinal fold with average depths of occurrence of the principal, possibly productive complex of 4, 2 and 5 km respectively. Of these, the most accessible for study were areas of the Karakul' arch: Sukhotinskaya, Vysokovskaya, Dzhakulevskaya and others (Fig. 2).

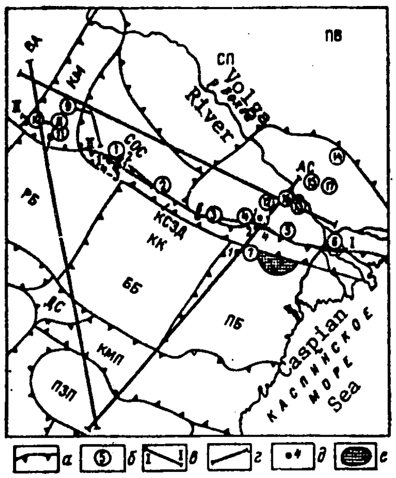

Fig. 1. Tectonic diagram of Kalmyk ASSR and Astrakhanian Povolzh'ye: *а*--boundaries of teconic elements; *б*--deep-drilling fields (numbers in circles): 1--Sukhotinskaya; 2--Alekseyevskaya; 3--Karakul'skaya; 4--Vysokovskaya; 5--Dzhakulevskaya; 6--Astrakhanskaya; 7--Krasno-Khuduk; 7--Umantsevskaya; 9--East Abganerovskaya; 10--Stepnovskaya (Karasal'); 11--Linstinskaya; 12--Stepnovskaya (Astrakhan'); 13--Pionerskaya; 14--Zavolzhskaya; 15--Aksaray; 16--Volozhkovskaya; 17--Shiryayevskaya; *в*--profiles; *г*--projected regional geophysical profiles; *д*--deep-drilling wells; *е*--region of erosion of Paleozoic carbonate formations. ПВ--Caspian depression; КК--Karpinsk ledge; ПБ--Promyslovskiy Block; ВА--Voronezhskaya anticlise; КМ--Karasal' monoclinal fold; СП--Sarpinskiy downwarp; СОС--Saygachinsko-Obil'nenskaya anticline; АС--Astrakhan' anticline; КСЗД--Karakul'sko-Smushkovskaya dislocation zone; ББ--Buzginskiy Block; РБ--Remontnenskiy Block; КМП--Kumo-Manychskiy downwarp; ДС--Divenskaya anticline; ПЗП--Prikumskaya zone of upheavals

Paleontologically characterized rocks of the Upper Carboniferous have been tapped by Vysokovskaya well No 4 and Sukhotinskaya well No 4. The Karakul' arch is revealed by seismic prospecting from a reflecting stratum confined to the roof of Artinskian formations. Despite considerable discrepancies (200-300 m) in the depths of occurrence of stratigraphic levels and their corresponding reference boundaries, the structure can be assumed to have been proved by deep drilling since the amplitude of the arch patently exceeds these discrepancies, ranging from 800 to 1500 m.

Signs of petroleum and gas show have been detected in only three of the eighteen wells sunk within the confines of the arch. In Vysokovskaya wells No 1 and 2 the petroleum yield was from 43 to 240 liters per day, and in Karakul' well No 5 in fissured blanket anhydrites of the Kungurian Era a brief influx of hot gas was observed from a small trap with anomalously high formational pressure.

The main reason for the negative results of prospecting on the Karakul' arch is the absence of collectors in subsalt Lower Permian-Upper Carboniferous formations. A monotonic stratum of unsorted terrigenous rocks of an Artinskian Molasse occurs extensively throughout the structure, which is a considerable detriment to the outlook for further petroleum and gas searches in this territory. Individual loops of better differentiated

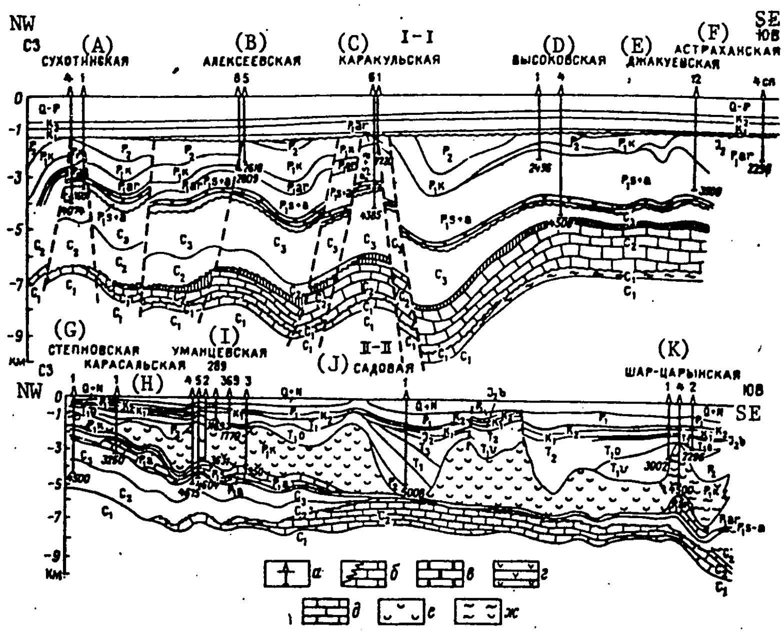

Fig. 2. Cross sectional profiles of the Karakul' arch (I-I) and the Karasal' monoclinal fold (II-II): *а*--deep-drilled wells; *б*--boundaries of facies change; *в*--dolomites; *г*--anhydrites; *д*--limestones; *е*--salts; *ж*--halopelites

KEY: A--Sukhotinskaya
B--Alekseyevskaya
C--Karakul'skaya
D--Vysokovskaya
E--Dzhakulevskaya
F--Astrkhanskaya
G--Stepnovskaya
H--Karasal'skaya
I--Umantsevakaya
J--Sadovaya
K--Shar-Tsarynskaya

sandstones, in the opinion of some geologists, may possibly exist, but the reservoirs that they form are apparently small. At the same time, the established oil and gas accumulations can be taken as evidence of new objects located in the vicinity of this structure. Their existence is confirmed by cores taken from Artinskian formations in the Vysokovskaya and Dzhakulevskaya fields, and Astrakhan' test well No 4. Seams of gritstones, gravel and conglomerates up to 15-20 m thick have been tapped in the upper part of Artinskian, predominantely argillaceous formations. Large poorly rounded detritus has been noted in the Dzhakulevskaya field, gravel in the Astrakhan' field, and gritstone in the Vysokovskaya field. These are limestones, effusives, flints, clay slates and anhydrites. It should be noted that there is nearly a total absence of feldspars. The clay slates in the detritus are enriched with sericite, and the flinty argillites are enriched with the remains of sponges and radiolaria. The fact that coarse fragments of limestones have been preserved in the redeposited form shows that they are comparatively close to the sources of drift, and the presence of gritstones, gravels and conglomerates localizes this source to the south of the Dzhakulevskaya field (Fig. 1). The limestone detritus shows microfauna of the Middle-to-Lower Carboniferous, i. e. in the Artinskian Era there was erosion of argillites of the Upper Carboniferous, limestones of the Middle and Lower Carboniferous, and possibly clay slates and deep-sea flinty argillites of a more ancient epoch, probably the Devonian. Since the wells of the Promyslovskiy Block show no Lower Permian formations, and the Bajocian sandstones at depths of 1500-2500 m lie on an eroded surface of more ancient formations, it is quite within reason that the preserved limestones of the Carboniferous are situated at accessible depths (3000-5000 m) on the periphery of the assumed region of erosion. In the tapped cross section of the Karakul' arch (see Fig. 2) between paleontologically characterized Artinskian rocks and argillites of the Upper Carboniferous there is an anhydrite-dolomite member (3196-3337 m) with seams of carbonate clays and argillaceous limestones in the base. This stratigraphic member has been conditionally assigned to the Sakmarian-Asselerian Era. It sinks from west to east, has a thickness of 200-293 m, and was apparently the only source of anhydrite detritus eroded in the Artinskian Era on a hypothetical upheaval to the south of the Dzhakulevskaya field.

Local structures mapped in the vicinity of the Karasal' monoclinal fold by seismic prospecting have been rather poorly confirmed by deep drilling. The results of sinking the first wells on the Umantsevskaya and East Abganerovskaya structures brought about a considerable change in the picture of the position of the anticline due to better definition of the depth of occurrence of salt, and the velocity characteristic of the cross section. Despite the low level of reliability of seismic plots, the high promise of the subsalt formations of the Karasal' monoclinal fold was proved by drilling. In Umantsevskaya well No 2, when the bottom hole reached 3631 m there was an open discharge of water with a yield of 5000 cu. m/day with a small admixture of petroleum (less than 15 cu. m per day).

Wells No 4 and 5 drilled later on this same structure show an absence of collectors in the subsalt formations represented by Asselarian-Artinskian anhydrites with occasional seams of dolomites and argillaceous limestones. Bioherms and biostromes were found as a result of drilling East Sharnut wells No 1 and 2 and Stepnovskaya well No 1 within the confines of the Karasal' monoclinal fold. The thickness of the layer of Asselarian-Artinskian sulfate-carbonate formations increases in this territory from west to east from 690 to 800 m, chiefly due to the development of Asselarian limestones of reef origin. Further on, deep into the Caspian depression, it thins out to 300-340 m. It is assumed that with regression of the sea in the Asselarian Era there was a migration of the biohermal zone from west to east along the southwest slope of the Voronezh anteclise. The cessation of miogeosynclinal activity in the vicinity of the Karpinsk ledge toward the beginning of the Early Permian, and the rise of this activity in the Sakmarian and Artinskian eras, i. e. the gradual abatement of the sea, suggests that there were three strata of bioherms and biostomes of the Asselarian, Sakmarian and Asselarian eras on the Karasal' monoclinal fold, and corresponding distributions of lagoon and reef facies in the cross section and through the course [Ref. 4].

Thus Asselarian-Artinskian limestones should be considered the main productive level of this zone. The main objects for search are the three assumed reef zones of the same era situated along the southeastern slope of the Voronezh anteclise.

In 1978 a gusher of petroleum gas with a yield of 5,000-8,000 cu. m/day was brought in from Artinskian dolomites in the Listinskaya well (interval of 2680-2730 m, open shaft).

Exploratory prospecting has been most successful on the Astrakhan' anticline. The first indications of gas from the subsalt formations (Artinskian limestones and argillites) were noted here by gas logging as early as 1970 in Stepnovskaya well No 1 at a depth of 4245 m; in 1971, column tests produced 200 liters of petroleum from analogous rocks in Pionerskaya well No 1 (3892-3977 m); in 1973 in Zavolzhskaya well No 3 the gas flow was 15,000-20,000 cu. m/day in assaying limestones of the Middle Carboniferous at a depth of 4260-4304 m; in 1975, there was a gas ejection accident in Aksaray well No 1 with the bottom hole at 3985 m in limestones of the Middle Carboniferous; in May 1976 in Volozhkovskaya well No 1 while assaying subsalt formations (3904-4100 m) with a stratum analyzer the yield of free-flow gas in drill pipes was 278,000 cu. m/day. In August 1976 in Shiryayevskaya well No 5, gas with condensate was obtained in tests of Bashkirian limestones in the drilling rig in the interval of 4070-4100 m; the yield of gas was up to 370,000 cu. m/day. In July 1977 in Volozhkovskaya well No 1 while studying objects in the drilling column (4060-4085 m) a gas-condensate gusher was brought in with a yield of up to 181,000 cu. m/day.

The main productive level -- Middle Carboniferous limestones -- is covered by a layer of dark gray to black flint-clay argillites of the Artinskian Era 50-150 m thick with seams of aleurolites, dolomites and limestones. To judge from petrographic studies, this layer accumulated under conditions of a deep open sea; it contains almost no collectors and is the main cover within the limits of the Astrakhan' anticline, beneath which are Middle Carboniferous formations with clearcut stratigraphic unconformity.

The change in thicknesses of halide-sulfate rocks of the Kungurian Stage -- from a few dozen meters in supersalt synclines made up mainly of argillaceous formations of the Upper Permian, to 3500 m on domes -- has no clear connection with the structural plan of the subsalt formations. This peculiarity of the geological structure in the aggregate with sharp variability of the velocity of propagation of oscillations over the area and through the cross section has apparently been the main reason for imprecise mapping of the roof of subsalt formations by seismic prospecting. Future areas for looking for petroleum and gas deposits within the confines of the Astrakhan' anticline could be associated with levels that obviously have their own structural plan, different from that of the roof of Middle Carboniferous limestones. These are apparently Lower Carboniferous limestones and formations of the carbonate Devonian in the crest section at depths of 5-6 km with a general cover of argillites of the Bobrikovskian level, and also super-Vereian limestones of the Upper and Middle Carboniferous along the periphery of the Astrakhan' anticline at depths of 4.5-5.5 km separated from the main productive stratum by a terrigenous Vereian layer of the Moscovian Stage of the Middle Carboniferous.

However, another facies habit of Upper Carboniferous formations is also possible. For example in the wells that are closest to the Astrakhan' anticline (Vysovskaya No 4 and Karkul'skaya No 6) the rocks of the Upper Carboniferous are made up chiefly of argillites. The same cross sections have been tapped on the Karasal' monoclinal fold, which is part of the Caspian depression. This shows the possible differentiation of the actual cross se[illegible] of the Upper Carboniferous of the Astrakhan' anticline from the assumed cross section. Therefore an important task of future studies in the southwestern part of the Caspian depression is to carry out regional geophysical research to reconstruct the history of development of the major tectonic elements of the region -- the Karpinsk ledge and the Caspian depression including the Astrakhan' anticline -- to construct a geological model from new theoretical standpoints with indication of assumed new and possibly productive strata and objects.

The reduction in thickness of Upper Carboniferous formations to the point of total extinction that has been established within the confines of the Astrakhan' anticline is apparently typical of the peripheral zone of the entire Caspian depression since it has been noted in fields of the Volga monoclinal fold, Aktyubinskian Uralia and South Embenskiy Rayon [Ref. 1, 5]. Therefore it cannot be ruled out that a productive level in the subsalt complex on the territory of the Saygachinsko-Obil'nenskaya anticline that we have distinguished will also be represented by Middle Carboniferous limestones. Its depth of occurrence in the crestal part of the upheavals found here reaches 5.5-6 km (see Fig. 2).

A comparison of cross sections of Artinskian formations of the Astrakhan' anticline, the Karasal' monoclinal fold and the Karakul' anticline shows sharp gradients of tectonic movements in the Artinskian Era, which under conditions of a warm sea with normal salinity that existed at that time could have been conducive to reef formation on the north of the Karakul' arch (10-15 km from its axis). It is possible that here between the

Molasse formations of a submerged Artinskian downwarp and thin planktonic sedimentations of the Astrakhan' anticline there was a band of bioherms and biostromes that can be considered as a new object for searches, and limestones of reef origin that can be considered as a potential productive stratum (see Fig. 2).

In the supersalt formations we can distinguish several possibly productive levels of the Triassic, Lower Cretaceous and Paleogenic eras, and a set of objects that are associated with salt-dome tectonics. The complexity of the geological structure of the traps, the intensive fractionation into blocks make it difficult to count on the discovery of even modest deposits, much less large ones, which has been evidenced by the long searches for salt domes.

However, despite the lack of success in searches for gas in supersalt strata, the work here should be continued since information on the depths of occurrence and the surface morphology of Kungurian salts is needed to improve the quality of geophysical research in mapping subsalt formations. This problem can be solved only by deep wells in which the supersalt stratum can be studied in addition to the investigation of the parameters of the cross section and the depths of the salt-bearing stratum.

There have been a few searches for small petroleum and gas deposits in Mesozoic formations on the Karpinsk ledge. This area of work is considered secondary in the Kalmyk ASSR and Astrakhanian Povolzh'ye since no appreciable deposits have been located here in the past ten years. The supply of local upheavals that have been prepared for deep drilling by seismic prospecting in this region is exhausted, and traps of non-anticlinal type in the productive levels of the Bajocian, Neocomian-Lower Aptian, Lower Albian and Upper Cretaceous eras contain no more than 10% of the proved reserves by an approximate estimate.

Within the limits of the Kumo-Manychskiy downwarp the productive level may be limestones of the Lower Triassic for which industrial oil and gas show has been proved on adjacent fields of the Prikumskaya zone of upheavals. So far there have not been enough prepared objects for searches in this area, but on the northern edge of the downwarp anticlinal bends have been found in a level occurring at a depth of 4.5-5.5 km, and juxtaposed with Lower Triassic limestones.

The geological criteria that have been considered above for the prospects of oil and gas show are not the only ones for the distribution of volumes of deep drilling with respect to objects. In addition, consideration is taken of technical and economic factors such as accessibility for drilling with respect to depth and with respect to other technical-geological particulars of the cross section (cave-ins, squeezing of the columns by salt, hydrogen sulfide aggression and so on), the amount of expended and proposed allotments for doing the work, time for realization of the forecast, distance from operating and planned petroleum and gas lines and so on. In the absence of a sufficient supply of prepared structures, geophysical research must be distributed in accordance with planned deep drilling objects. With consideration of the criteria for outlook evaluation and the importance for prospecting objects that are known in the Caspian depression and its environs, priorities must be set for doing geophysical research in groups of jobs.

The first group includes the most promising areas with anticipated maximum geological information; they should be the object of investigation by geophysical methods in the next 2-3 years:

mapping of the eroded surface of limestones of the Middle Carboniferous within the limits of the Astrakhan' anticline to determine the outlines and dimensions of Middle Carboniferous gas-condensate deposits;

mapping the surface of limestones of reef origin of the Asselarian-Artinskian Era on the Karasal' monoclinal fold;

deep-drilling preparation on structures that touch the steep slopes of salt domes, and large tapering zones in sandstones of the Lower Triassic of the salt-dome region in the Caspian depression;

preparation of objects for deep drilling on subsalt formations of the Saygachinsko-Obil'nenskaya anticline;

mapping of the carbonate Permian-Triassic complex and determining the northern line of abrupt tapering of this complex in the Kumo-Manychskiy downwarp.

The second group includes objects that should be the subject of study by geophysical methods in the next 5-6 years:

mapping of the Astrakhan' anticline with respect to deep-lying formations to determine its internal structure and optimum conditions for sinking the first deep wells to Lower Carboniferous and Devonian formations;

deep-drilling preparation on objects of the Karakul'sko-Smushkovskaya dislocation zone on the surface of limestones of the Carboniferous-Lower Permian.

The third group includes objects that should be the subject of study by geophysical methods beginning in the last years of the 11-th Five-Year Plan:

laying out regional profiles by a complex of geophysical methods to determine the type of crystalline crust of the Sarpinskiy downwarp, the Karpinsk ledge and the Astrakhan' anticline (Fig. 1);

developing methods to locate and map Artinskian bioherms on the north wing of the Karakul' arch;

developing a technique for mapping traps under overhanging projections in the salt-dome region of the Caspian depression.

The proposed list of major objects for geophysical study is also applicable to the selection of promising areas of deep parametric and exploratory drilling. However, the specific volumes of this work depend on the results of preceding geophysical studies.

Implementation of the planned program of geological-geophysical studies within the confines of Kalmyk ASSR and Astrakhanian Povolzh'ye will enable an organized investigation of promising territories of the southwest part of the Caspian depression, and will accelerate the discovery and industrial introduction of the largest objects.

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FUELS

UDC 553.98:550.812(574.14)

NEW EXPLORATION TARGET ON MANGYSHLAK PENINSULA

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 12, Dec 79 pp 19-23

[Article by I. A. Khafizov, V. V. Kozmodem'yanskiy, P. Ye. Korsun and V. A. Pankov]

[Text] Soviet and non-Soviet experience in geological prospecting for oil and gas shows the increasing significance of searches for petroleum and gas in traps of non-anticlinal type, especially in zones of oil and gas accumulation formed by facies changes, among which we can also include zones of development of submerged river systems. The oil and gas show of such systems has been proved in various regions, including Mangyshlak [Ref. 5].

Geomorphologically and with respect to sedimentation conditions, the river valley and the delta correspond to the river system. Statistical data show [Ref. 4] that the sedimentary formations of paleodeltas are of considerable interest for oil and gas prospects. A known deposit of this type in the United States at Prado Bay contains 1350 million metric tons of petroleum and 728 billion cu. m of gas. There are also considerable reserves of oil and gas confined to delta formations in various parts of the Soviet Union; their stratigraphic range is from the Neogenic to the Lower Paleozoic.

As a result of seismic prospecting by the common depth point method carried out on South Mangyshlak, a possible trap has been found in the vicinity of Kosa Ada that is associated with a paleodelta in Oligocene formations. According to microfauna and palynological data, the cross section of the Oligocene is subdivided into four series, while electrical logging subdivides it into seven stratigraphic members [Ref. 3].

The base of the Kuyulusian series of the Lower Oligocene and the roof of the Kendzhalinskian series of the Middle Oligocene are the reflecting levels A and B (Fig. 1). They are tied in to the cross sections of deep exploratory wells (Aksu-Kendyrli No 6, Temirbaba No 4, 6). The rocks of this member on Mangyshlak are represented by two lithological-facies

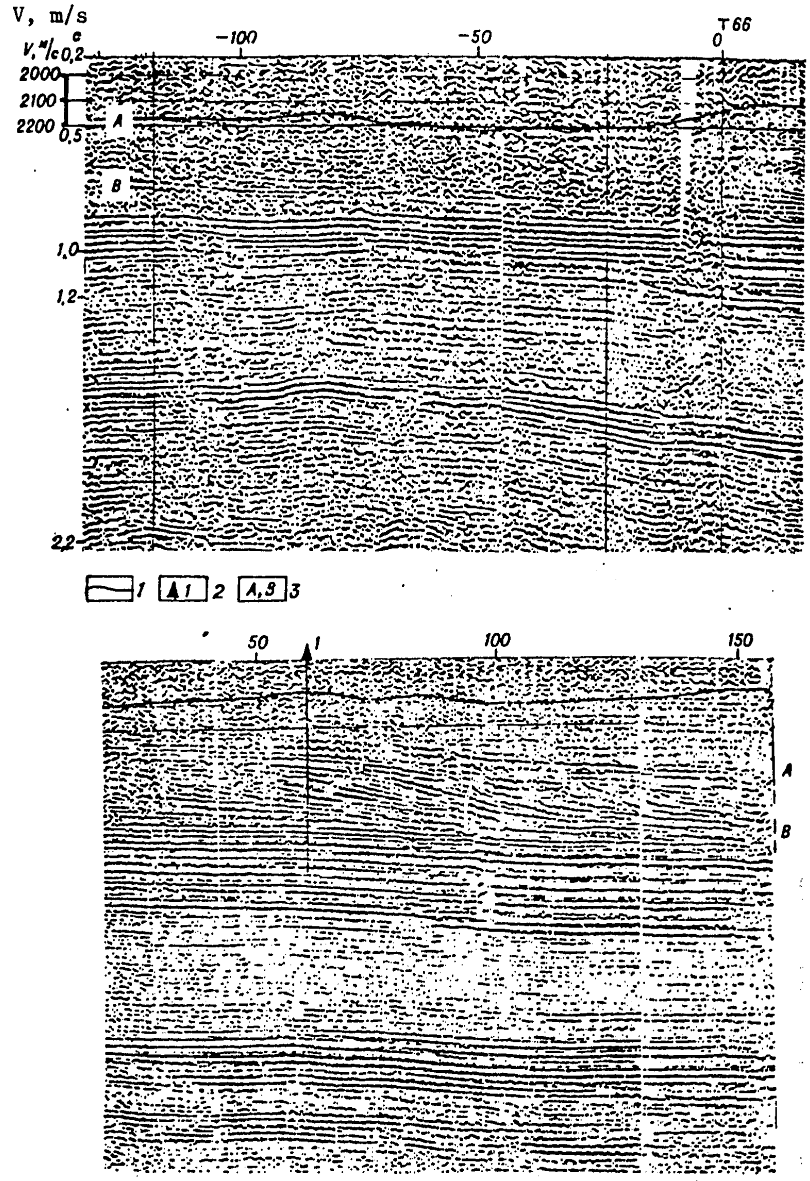

Fig. 1. Time section through profile No 67: 1--seismic velocity curve; 2--planned well; 3--reflecting levels in Oligocene formations

varieties: a deep-sea facies of Burlinskian type, and a littoral facies of Chakyrganskian type. The formations of the latter facies, which can be categorized as bay and gulf facies where deltoid sediments have probably accumulated, have so far been found only in the Chakyrganskian downwarp. However, similar formations are doubtlessly present everywhere in regions neighboring paleocoastal zones. The territory of Kosa Ada, situated to the north of the Karabogaz anticline is just such a region.

An analysis of the amplitudes of the reflection confined to the roof of the member that includes formations of an assumed ancient delta on profile No 67 (Fig. 1) shows that its amplitude increases on the section in the interval of pickets 20–150, i. e. directly above the oblique reflections, in contrast to the left part of the cross section. This shows a change in the coe.ficient of reflection in the given part of the profile, and accordingly shows a change in the lithology of the stratigraphic member of the underlying rocks.

The form of the anomaly is analogous to the appearance of a "bright spot" effect that is taken by seismic prospectors as an encouraging sign typical of gas traps occurring close beneath the surface. The same effect is observed on profile No 66 between pickets 80 and 150.

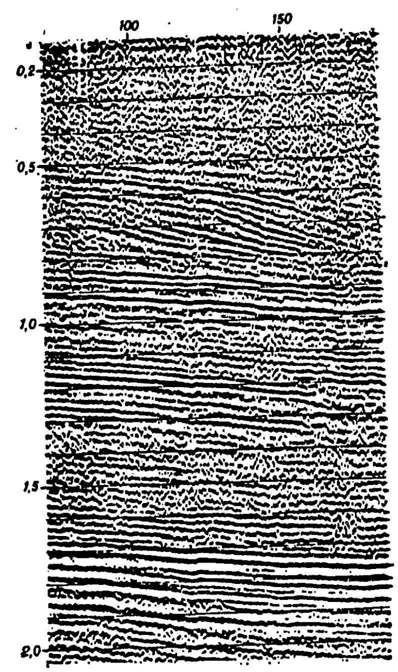

Fig. 2. Time section through profile No 66

On the upper part of the cross section through profile 67 (Fig. 1), data are entered to scale from horizontal analysis of seismic velocities of the reflection member. Between pickets 0 and 150 we see a considerable reduction in seismic velovity from the 2200 m/s typical of the left part of the cross section to 2050 m/s at picket No 60. It is noteworthy that this decrease in velocity corresponds to the zone of registration of oblique reflecting stages and the region of increasing amplitudes of reflection from level A in the roof of the member. The reduction in seismic velocity along the profile is evidence of replacement of the rocks in this member over level B by more porous varieties.

Thus our analysis of seismic material on the Kosa Ada field for determining the confinement of reflections from the stratum boundaries observed between levels A and B shows that this stratum corresponds to paleodeltoid formations. This is evidenced by: a) the general form of the wave field between levels A and B, characterizing unidirectional oblique layering inherent in the metamorphic formations of a delta; b) an abrupt change in the amplitude of the reflection from level A that covers the assumed paleodeltoid formations, which is due to the change in lithology of this member, i. e. a change in the coefficient of reflection on boundary A through the profile of observation; c) a reduction in seismic velocities up to boundary B, due apparently to an increase in porosity of the sediments in the vicinity of the obliquely layered formations; d) localization of the zone of anomalies and coincidence of this zone with respect to all parameters.

A sunken delta can be hypothesized here on the basis of experience in comprehensive interpretation of seismic materials of the common depth point method combined with data of velocity and amplitude analyses of the reflections, analogs of the wave field on known examples, and also data of industrial geophysics and geological information on the Kosa Ada region. The contour of the deltoid formations against a background of thickness distribution over the area between reflecting levels A and B is shown in Fig. 3.

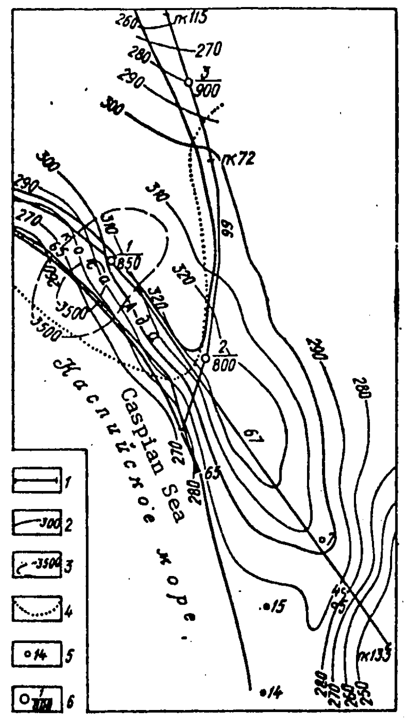

Fig. 3. Map of thicknesses between levels A and B: 1--seismic profiles; 2--isopachs between levels A and B, m; 3--isohypses from the pre-Jurassic reflecting level, m; 4--boundary of the extent of deltoid sedimentations; wells: 5--drilled; 6--planned

Data on the oil and gas show of Oligocene formations are of interest in light of the question under consideration. This stratum is the regional cover on most of the territory of Mangyshlak. However, in isolated zones (in particular in North Prikarabogazia) the Oligocene formations cease to perform this function due to sandstone intrusion in the cross section. For instance on the Aksu-Kendyrli field in the central part of the Oligocene cross section we note a thick member (up to 65 m) of sandstone and aleurolite interlayered with clays. This part of the cross section has its lithological analog in the wells of drilled fields of North Prikarabogazia. The upper part of this member has been assayed in the open bottom hole of Aksu-Kendyrli well No 14 in the interval of 415-439 m with production of a free gas flow of up to 20,000 cu. m/day through a 24-mm pipe.

Typically, gas logging in several wells has shown high-hydrocarbon anomalies confined to the given regions of this cross section of Paleogenic formations.

The aggregate of the data given here realistically indicate potential oil and gas shows of Paldogenic formations over a considerable territory. This fundamental conclusion puts prospecting for oil and gas traps in rocks of the Paleogenic Era among jobs of first-rank importance.

Clearly of topical concern in this connection are the results of seismic prospecting by the common depth point method in the vicinity of Kosa Ada, where a type of potential hydrocarbon trap that is entirely new for Mangyshlak will probably be found.

On the basis of everything that has been said here, we can suggest drilling three exploratory wells with projected depths of 800-900 m to study the collector properties, the nature of sedimentation and the oil and gas shows of the assumed paleodeltoid formations of the Paleogenic in the 450-900 m interval. The placement of the wells should be dictated by the outline of the occurrence of deltoid sediments and by the hypsometric location of the investigated section of the Paleogenic elevation.

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