EXPERIENCE IN THE CONSTRUCTION OF LARGE
POWER REACTORS IN THE USSR

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In the directives of the 24th Congress of the Communist Party of the Soviet Union, among the problems related to the development of power generation in the country, reference was made to the need to put into operation during the 1970-1975 period the Leningrad Atomic Power Station (LAPS), which will have a capacity of 2,000,000 kW. This means a very substantial introduction of nuclear-fission energy into electrical power generation in the coming years. The task assigned by the directives was fulfilled; the first reactor, with an electrical power of 1,000,000 kW, began operation in December 1973 and achieved full power by the 57th anniversary of the October Revolution; the second reactor, identical with the first, went into operation in August 1975, and by December 1975 its power output was approximately 900 MW. The second reactor will also undoubtedly achieve full designed power in the near future. The LAPS, named for the great Lenin, is equipped with channel-type uranium—graphite reactors (RBMK), which have been described repeatedly in the literature [1-4]. The theoretical and engineering principles of this reactor were developed and tested in practice in the Soviet Union, and therefore it can rightfully be regarded as a Soviet type of reactor. The construction and introduction into operation of the LAPS reactors means that one more important landmark has been passed in the process of improving and developing this type of reactor, the conception of which dates from the late 1940's, when the first such reactors were constructed, including the reactor of the world's first atomic power station at Obninsk. The next landmark was the start-up in 1958 of the reactor of the Siberian Atomic Power Station, a film of which was shown, in particular, to the participants in the 2nd International Conference on the Peaceful Uses of Atomic Energy, held at Geneva in the same year. After this, in 1964, the channel-type uranium—graphite reactor of the I. V. Kurchatov Atomic Power Station at Beloyarsk was put into operation. In 1967 a second reactor, with an electrical power of 200,000 kW, was started up at Beloyarsk. These reactors, based essentially on the same technological idea, differ in principle in that, first of all, their fuel channels are cooled by boiling water and, second of all, the steam generated is superheated in special channels in the same reactor. More than 12 years of operation of the reactors of the Beloyarsk APS have confirmed the viability of such a solution. It should be noted that such solutions, carried to the point of satisfactory results, do not exist in any other country in the world, despite many attempts that have been made. Nuclear superheating of steam before it enters the turbine is a very tempting idea, since it not only prevents the danger of wet steam entering the turbine but also makes it possible to do without the intermediate moisture separators and without superheating of the steam between turbine stages, which in turn makes it possible to simplify the production of steam in the reactor. For turbines with large power, e.g., over 800 MW, which may be required in the construction of large atomic power stations, the initial superheating of the steam makes it practical to use a speed of 3000 rpm instead of the 1500 rpm now used in operation with saturated steam. Another significant fact is that the efficiency of the entire installation is improved.

The reactors of the LAPS, like those of a number of other APS now under construction, have no channels for the superheating of steam and produce dry steam, obtained in channels with boiling water in a single-loop scheme and transmitted directly to the turbine. As a consequence of this, it is necessary to include between the stages of the turbine a number of moisture separators and steam superheaters. The next stage in the improvement of channel-type uranium—graphite reactors will undoubtedly be the introduction into the active zone of channels for the superheating of the steam. This will come with the next generation of reactors. They will have an electrical power of 2-3 million kW; the reliable operation of such reactors will be based on the experience obtained in the operation of reactors now under construction, with the complex physics of their large active zones and with the use of modern computers for detecting at the proper
time the phenomena going on in the active zones and the effects on the automatic control devices. We must believe that scientific and technical progress in the next few years, particularly in the fields of metallurgy, physical chemistry, and instrument design, will lead to the realization of these ideas as early as the next 5-10 years.

The theoretical thermal scheme of the V. I. Lenin APS is shown in Fig. 1. It is a single-loop scheme, which differs from the known schemes for boiling reactors. The difference lies only in the design of the reactor, in the present case an RBNK-1000 channel-type uranium–graphite reactor. In estimating the advantages of this type of reactor, the following considerations are weighed: the existence of extensive experience in the construction and operation of similar reactors; the absence of any specific and new technological processes, so that it is possible to get orders filled by the machine-construction industry without unduly great expense for the retooling of factories, and consequently, without requiring very long delivery times; the possibility of constructing reactors of any dimension by using mass-produced elements and assemblies, i.e., there are practically no limitations on the increase of the unit power of the channel reactors; the structural separation of the moderator and the coolant, making possible a fairly flexible choice of the substances and materials used for them, thereby ensuring effective heat removal in the active zone, with good neutron balance; the possibility of recharging an operator reactor with fuel without reducing the power, thus improving the economic indicators of the atomic power station, since in this case there is practically no need of a reactivity excess for fuel burnup; the simplification of the system for monitoring the condition of each channel, and the possibility of operational replacement of fuel assemblies which have developed leaks; the fact that the cooling loop of the reactor consists of many smaller loops of small-diameter pipe, improving the safety of the installation; the possibility of easily adapting the reactors to the conditions of the fuel market; the possibility of continuously introducing new structural elements and assemblies, with the use of the most modern advances in nuclear-fuel and reactor-material production technology; the convenience and simplicity of introducing nuclear superheating of steam into the scheme of the APS.