NOTES ON THE HISTORY OF THE FIRST ATOMIC REACTOR IN THE U S S R

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A short description of the activities connected with the construction of the first atomic reactor in the Soviet Union was given as long ago as July 1955 by Professor V.S. Fursov of Moscow University at a session of the USSR Academy of Sciences devoted to the peaceful uses of atomic energy. Professor Fursov's report was published the same year.

In the initial stage of research on the realization of a nuclear chain reaction, Soviet scientists could rely on obtaining uranium of natural isotopic composition only, and hence for the establishment of conditions under which the uranium fission reaction would go it was necessary to moderate the fast neutrons formed during fission, thus turning them into thermal neutrons and avoiding significant neutron loss. Graphite was chosen as moderator for the reactor.

The considerable amount of experimental research which had already been carried out on measurement of the neutron and nuclear values of graphite and uranium was utilized in the theoretical calculations from which the practical possibility of a nuclear reaction in a uranium-graphite reactor was inferred.

The aim was to create a system of natural uranium and graphite and attain therein a neutron multiplication factor greater than unity.

Nevertheless, after much research and experimentation there was, as Professor Fursov stated in his report, "no absolute certainty of the final success of the efforts to bring about a chain reaction in a natural uranium-graphite system, and there were for that reason some grounds for considering the impending construction of a uranium-graphite reactor, not as an undertaking fairly certain of success, but as a vital experiment in the measurement of the nuclear constants of a uranium-graphite system".

In order to make a chain reaction possible in a uranium-graphite pile, the latter must have sufficiently large dimensions. Calculations showed that for the establishment of these conditions 25 to 50 tons of uranium metal and several hundred tons of graphite would be required.

To implement the project it was necessary not only to solve complex physical problems, but also to obtain uranium metal and graphite of a degree of purity hitherto undreamed of by any branch of industry.

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Many complex questions arose which had to be solved rapidly.

Techniques were required for purifying graphite, for deriving uranium compounds, and for producing uranium metal, refractory materials for the manufacture of crucibles used in smelting uranium, and also many other materials needed for the undertaking.

High purity demands were made on all these materials. Some impurities were hunted down in the same way as a passionate and tenacious hunter tracks rare game. It was at that time that the expression "foreign atoms" became current among the experts engaged in developing technologies for the production of pure uranium and graphite. Keen discussion arose as to how many "foreign atoms" could be permitted per million uranium atoms.

However, it cannot be said that the start of work on building the first atomic reactor found Soviet experts unacquainted with uranium. Work on uranium was begun by Russian scientists as long ago as the beginning of this century. The discovery of radium in 1898 by M. Sklodowska-Curie and P. Curie, and the interest shown in this new and unusual element, aroused the attention of scientists in Russia also.

The study of radioactive materials was started at Moscow University shortly after the discovery of the phenomenon of radioactivity.

Professor A. P. Sokolov, of Moscow University, ascribed great importance to the study of radioactivity and organized research on rocks, water, therapeutic mud and the causes of ionization of atmospheric air. As long ago as June 1903 he wrote a paper entitled "Ionization and Radioactivity of the Atmospheric Air", and in December of that year he published a paper calling for a study of the distribution of radioactive elements in Russia.

Professor Sokolov established contact with mineralogical institutes and experts in regional matters even in the most remote districts of Russia. As a result, copious samples of minerals, ores and mineral spring water from various parts of the country began to arrive at the radiological laboratory of Moscow University Physics Institute for analysis.

In 1910, Professor V.I. Vernadsky, also of Moscow University, and curator of the mineralogical collection, called attention to the need to study radioactive mineral deposits in Russia. In his paper "The Need to Investigate the Radioactive Minerals of the Russian Empire" he noted in the following words both the scientific and theoretical and the social and political importance of radioactivity: "The more closely we investigate the phenomena of radioactivity, the more important becomes their significance for us, ... and the nearer we approach to fundamental criticism and revision of the age-old tenets of scientific knowledge .... We recognize the inevitability of gigantic changes in the conditions of human existence once man has mastered radioactive phenomena, even if only to the extent that he has mastered the power of steam or electricity .... "

The first studies of radioactive minerals in Russia were carried out during the period 1900-1903 by Professor I. A. Antipov, who devoted particular attention to the Fergana district.

In 1909 Professor P.P. Orlov, working at Tomsk, began research on the radioactive minerals of Siberia, and in the same year, on the initiative of Professor Vernadsky, the Russian Academy of Sciences began attempts to organize the study of radioactive minerals on a large scale and according to a definite plan.

In 1908 the private "Fergana Rare Metal Mining Company" was established, and began to extract ore and export the uranium, vanadium, and copper concentrates obtained therefrom. The company established contact with Marie Curie's laboratory, and, at the request of the former, one of her collaborators went to Russia.

After the October Revolution scientific research in Soviet Russia started to undergo extensive development, which also covered work on uranium.

In 1918 the Radium Institute was established in Leningrad by decree of the Soviet Government, and became the scene of considerable studies on uranium and other radioactive elements.

Subsequently, an independent geochemistry laboratory, named after V.I. Vernadsky, was organized separately from the Radium Institute, and later became the USSR Academy of Sciences' Institute of Geochemistry and Analytical Chemistry.

Recognizing the importance of work on rare and sparsely distributed elements, the Soviet Government in 1932 set up a special institute for research on these elements, and there was thus established yet another facility not only for the conduct of fundamental research on the properties of rare elements and their compounds but also for the development of rational technological processes for obtaining them; this institute was called the State Rare Metals Institute.

In these three institutes there were worked out technological processes for extracting uranium from ore, for purifying uranium compounds and for testing uranium for content of impurities.

Thus, when the first Soviet atomic reactor was built, the scientific organizations of the country already had at their disposal teams well acquainted with the problem and with the complex experimental technique of work with radioactive elements.

However, the great difficulty of producing very high purity uranium raised fresh problems, which required the application of expert labour and ingenuity.

The Soviet chemical industry did not produce many high purity chemicals, and chemical apparatus contained certain elements (such as boron in glass and enamels) which brought about contamination when the apparatus was used. It was therefore necessary to develop special materials for the manufacture of laboratory instruments and production plant, in order to eliminate the possibility of contamination of the uranium compounds and uranium metal.

Work on metallic uranium was begun in Russia very long ago. Even before the first world war Professor N. P. Chizhevsky had started his first experiments on extracting uranium metal and studying its effects on the properties of steel.

Professor Chizhevsky attached great importance to the purity of uranium and ascribed the failures of certain research workers to the fact that they were using oxidized uranium, containing admixtures of other elements.

At the State Rare Metals Institute the experiments on derivation of pure uranium and thorium led to the development of industrial processes for the production of the metals in pure form. Thus, the principles of the technology of pure uranium and thorium production were known to Soviet experts, but it was necessary to perfect the technology of producing metal of reactor purity and to set going in the USSR the production of the necessary chemicals and reagents, to construct the essential instrumentation and apparatus and to introduce appropriate methods of testing and control.

There was a small output of graphite products in Russia even before the first world war, but production of these items on a modern scale began in the Soviet era, at the beginning of the 'thirties. The first graphite products were manufactured in 1935 at the Chelyabinsk electrode factory. The activities at Chelyabinsk attracted experts from other cities of the Soviet Union, which resulted in the formation of a team of engineers familiar with the details of the technological process. This factory subsequently became a school for training staff for other electrode plants.

Thus, when it became necessary to organize production of uranium and graphite for the first Soviet atomic reactor, this task, although difficult, was facilitated by the availability of teams of highly trained experts, who in a short time succeeded in placing at the disposal of the physicists engaged on the construction of the reactor both uranium and graphite of a quality in full accordance with the stringent purity requirements essential for a nuclear chain reaction.