

CONFERENCES AND SYMPOSIA

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ON 80th ANNIVERSARY OF VICTORY IN GREAT PATRIOTIC WAR

Kurchatov Institute for science of the Great Victory *

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Contents

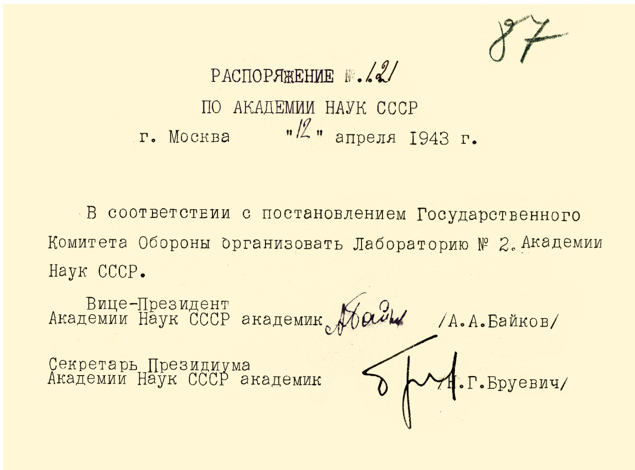
Abstract. **For Soviet science, the years of the Great Patriotic War were a time to search for and quickly implement the most daring scientific and technical solutions to speed our Victory. One such example was applied practical work on demagnetization of ships, headed personally by A.P. Aleksandrov. As a result, a system for protecting ships from magnetic mines was deployed, saving hundreds of vessels and countless lives. Despite the numerous important tactical tasks that the front urgently needed to address, Soviet scientists and the USSR leadership clearly identified a long-term strategic priority: the Soviet Atomic Project. Under the scientific leadership of I.V. Kurchatov, the task was successfully completed — within six years, our country's nuclear shield was forged.**

Keywords: demagnetization, nonwinding method, Atomic Project, self-sustaining chain reactions, uranium-graphite reactor

"Modern warfare is not only a war of tanks, aircraft, and manpower, but also a war of scientific laboratories."
Igor' Kurchatov, 1942

1. Introduction

The Great Patriotic War was in full swing when the leaders of our country decided to resume uranium research activities. On September 28, 1942, the State Defense Committee issued Order No. 2352ss, instructing the USSR Academy of Sciences "to resume research into the feasibility of using atomic energy by fissioning the uranium nucleus and to submit a report on the possibility of creating a uranium bomb to the State Defense Committee by April 1, 1943" [1]. The first step was to organize a special laboratory of the atomic nucleus (Fig. 1).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РАСПОРЯЖЕНИЕ №.121
ПО АКАДЕМИИ НАУК СССР
г. Москва "12" апреля 1943 г.

В соответствии с постановлением Государственного Комитета Обороны организовать Лабораторию № 2. Академии Наук СССР.

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Figure 1. Order No. 121 for USSR Academy of Sciences to organize Laboratory No. 2 of USSR Academy of Sciences. Moscow, April 12, 1943. Copy. Archive of National Research Center Kurchatov Institute. F.1, OP.2, D.2065, L.3.

Laboratory No. 2 of the USSR Academy of Sciences was founded on April 12, 1943. This is the official birthdate of this unique scientific organization responsible for breakthroughs not only in atomic weapons but also in all areas of the 'peaceful atom.'

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The very small staff of Laboratory No. 2 (100 people in 1944, including support personnel) [2] in a war-torn country had to join the atomic race, primarily against the scientists of the Manhattan Project, who were developing nuclear weapons in the United States, with almost unlimited material, technological, and human resources.

The leadership of the Soviet Atomic Project was entrusted to Igor' Vasil'evich Kurchatov, a 40-year-old physics professor [3]. The laboratory researchers called Kurchatov 'our general' or 'our commander.' He truly led the researchers and, together with his 'soldiers' — the scientists — saved our country and the world from nuclear catastrophe.

2. Anticipating the atom

The backbone of the future laboratory was made up of scientists from the 'special group on the nucleus' of the Leningrad Physical-Technical Institute (LPTI). In the 1930s, A.F. Ioffe brought together the cream of scientists and engineers of Soviet atomic physics at the LPTI: young scientists A.P. Aleksandrov, A.I. Alikhanov, L.A. Artsimovich, B.V. Kurchatov, V.A. Davidenko, V.P. Dzhelepov, I.K. Kikoin, M.S. Kozodaev, L.M. Nemenov, P.E. Spivak, G.N. Flerov, and many others. They closely collaborated with Yu.B. Khariton and Ya.B. Zel'dovich from the Institute of Chemical Physics. Later, S.A. Baranov, I.N. Voznesenskii, I.N. Golovin, V.V. Goncharov, I.I. Gurevich, V.I. Merkin, M.G. Meshcheryakov, I.S. Panasyuk, M.I. Pevzner, I.Ya. Pomeranchuk, and N.F. Pravdyuk became part of Kurchatov's team.

In the pre-war years, thanks to scientific schools at the LPTI, the Radium Institute, the Lebedev Physical Institute, and the Kharkov Institute of Physics and Technology, nuclear physics research in our country was on a par with the best laboratories in the world.

Let us briefly review a few important milestones. In 1932, a special group on nuclei was organized at the LPTI under the leadership of I.V. Kurchatov (Fig. 2), which a year later was transformed into the Department of Nuclear Physics. In 1934, A.F. Ioffe made nuclear research the central activity at the LPTI, and solid-state physics the second most important. In 1935, I.V. Kurchatov published a monograph entitled "Splitting the Atomic Nucleus." He led a weekly seminar, which the participants would later call the "School of Neutron Physics." In 1936, I.V. Kurchatov and his colleagues discovered the phenomenon of nuclear isomerism. Five scientific conferences on nuclear physics were held in the USSR in the 1930s, with the participation of foreign scientists.

In 1939–1940, Kurchatov's postgraduate students Georgy Flerov and Konstantin Petrzhak, under his supervision, performed experiments and were the first to detect nuclear fission in an ionization chamber — the spontaneous splitting of uranium proceeded without neutron bombardment. Igor' Vasil'evich insisted on a control experiment. It was conducted at night at the Dynamo station of the Moscow metro to rule out the influence of cosmic rays. In 1940, Yulii Khariton and Yakov Zel'dovich formulated the conditions for a self-sustaining nuclear chain reaction [4, p. 217]. A year later, Leo Szilard and Enrico Fermi proposed using graphite as a moderator to initiate chain reactions.

In 1939–1940, a number of articles were published confirming that both Soviet and foreign scientists were moving closer to creating a new, super-powerful weapon.

Figure 2. Professor Igor' Vasil'evich Kurchatov of Leningrad Physical-Technical Institute, 1930s. Archives of National Research Center Kurchatov Institute.

The level of theoretical and experimental work by Soviet physicists in this field was high. In 1940, at the V All-Union Conference on the Physics of the Atomic Nucleus, I.V. Kurchatov, in his review report, discussed the fundamental possibility of solving the problem of harnessing intranuclear energy in the process of uranium chain fission: "For the chain to be sustained, it is only necessary that at least one of the several secondary neutrons emitted during fission lead to further fission" [5, p. 315].

"Kurchatov relied primarily on the calculations of Zeldovich and Khariton and some other Soviet research papers. He clearly indicated that the problem of the feasibility of a fission chain reaction had been fundamentally resolved positively: two paths were visible — either the use of ordinary uranium mixed with heavy water as a neutron moderator, or the use of uranium enriched in the 235 U isotope mixed with ordinary water or, possibly, other light substances (for example, carbon), if it turns out that they have a sufficiently small neutron capture cross section" [6, pp. 104–105].

The significance of energy release processes during a fission chain reaction for military purposes also became obvious. I.V. Kurchatov sent a plan for the development of work on nuclear chain reactions to the Presidium of the Academy of Sciences [7, p. 142]. And, if not for the war, as K.A. Petrzhak noted later, "then Soviet physicists would not have lagged behind the Americans in any way, and perhaps would have achieved a chain reaction before 1942" [8, p. 6]. A similar opinion was shared by American physicist and

Manhattan Project participant Ralph Lapp, who wrote, "Fanatic emphasis in U.S.A. upon atomic secrecy obscured the fact that the Soviets had perfectly good scientists who could find the answers for themselves. No law of nature makes science different on either side of the Iron Curtain" [9, p. 146].

3. Beginning of Atomic Race

From the end of 1940, all publications on atomic topics disappeared from scientific journals. Germany, Great Britain, and the United States completely classified their work in nuclear physics. The world was just moments away from creating a bomb, and the atomic arms race began.

In 1939, the German Army Ordnance Office, with the help of leading German physicists, decided to implement the Uranium Project program to develop nuclear weapons. In early 1940, German scientists calculated the critical mass of a nuclear charge and mastered the technology for producing metallic uranium, fabricating prototype centrifuges for separating its isotopes.

In the summer of 1940, the Manhattan Project was set up in the United States, involving many renowned scientists — immigrants from Europe. A total of approximately ~ $200 billion, in today's dollars, was allocated for the project.

Also, on July 30, 1940, the Uranium Commission was established at the USSR Academy of Sciences, chaired by V.G. Khlopin and deputies V.I. Vernadskii and A.F. Ioffe. Its members also included P.L. Kapitza, A.E. Fersman, I.V. Kurchatov, and Yu.B. Khariton, and others [7, pp. 127–128]. The Commission was assigned the tasks:

• to define the scope of research projects at the institutes of the USSR Academy of Sciences in the field of uranium studies;

• to organize the development of methods for separating or enriching uranium isotopes and research into the control of radioactive decay processes; and

• to coordinate and provide general guidance to research on uranium at the USSR Academy of Sciences.

By early 1941, Soviet scientists were searching for effective ways to isolate the active isotope (uranium-235) and were studying various moderators (heavy water, helium, and carbon) necessary for a self-sustaining chain reaction. On June 22, 1941, construction of the largest cyclotron in Europe at the time was completed at the Leningrad Physical-Technical Institute. Its scientific design and construction were supervised by I.V. Kurchatov. The outbreak of the Great Patriotic War interrupted this work.

Some of the LPTI researchers were evacuated to Kazan, and many went to the front. I.V. Kurchatov was also eager to fight. "...After the war with German fascism began, he categorically refused to continue working in the field of pure science and wanted to go to the front immediately. The most drastic measures had to be taken to convince Kurchatov to remain at the Institute; he then categorically demanded from the Institute's directorate work that could contribute to the victory of the Red Army. He received this work and carried it out literally heroically under combat conditions" [10].

4. Demagnetizers

A.F. Ioffe sent I.V. Kurchatov to A.P. Aleksandrov's Laboratory of Electrical and Mechanical Properties of Polymers [11, p. 20] (Fig. 3).

Figure 3. Professor Anatolii Petrovich Aleksandrov of Leningrad Physical-Technical Institute, 1930s. Archives of National Research Center Kurchatov Institute.

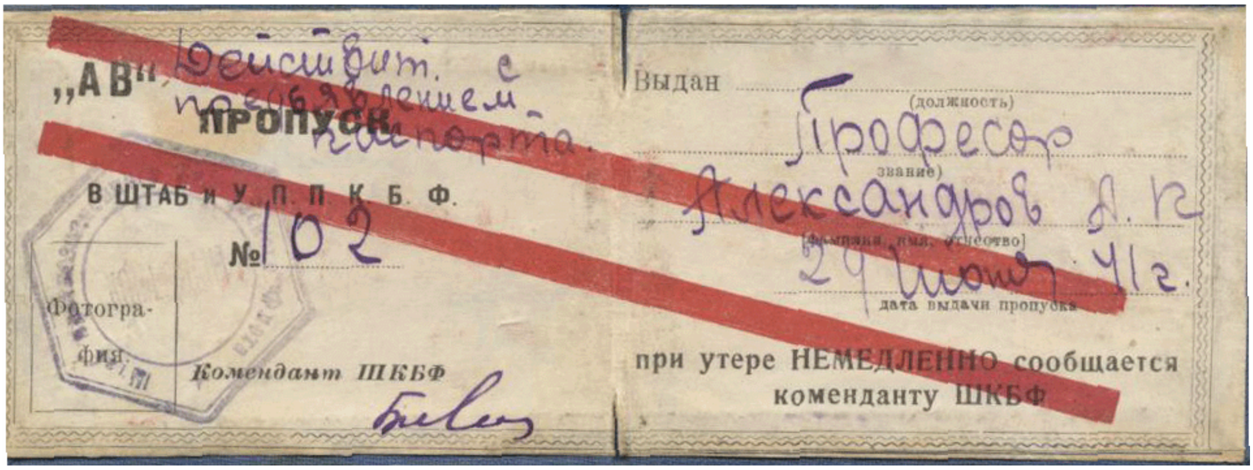
It was in that tragic summer of 1941 that the close collaboration between these two great men, Igor Kurchatov and Anatolii Aleksandrov, began. Largely thanks to this collaboration, the Soviet Atomic Project came to fruition, ensuring the sovereignty and national security of our country to this day.

The first major undertaking that united these future comrades in the Atomic Project was demagnetization of ships, vital work for our Navy at the time. In fact, the British had already used contactless magnetic mines very effectively during the years of the intervention and civil war of 1918–1922 against the Soviet White Sea Flotilla.

"Academician A.F. Ioffe, director of the Leningrad Physical-Technical Institute, was in a constant search for practical applications of the results of fundamental physics in a wide variety of fields, including national economy and defense; many of his students shared the same 'searching nature.' A.P. Aleksandrov believed that each laboratory of the institute, in addition to its main scientific topic, should participate in defense work" [12, p. 37].

In 1936, the Navy command set the People's Commissariats (Narkomats) of Heavy and Defense Industry the task of providing new warships with protection against noncontact mines and torpedoes. The design bureau of the plant, which was part of the People's Commissariat of Heavy Industry (the Leningrad Physical-Technical Institute was also assigned to this Narkomat at the time), signed an agreement with the polymer laboratory of the Leningrad Physical-Technical Institute (directed by A.P. Aleksandrov) [13, p. 21].

In just a few months, A.P. Aleksandrov, B.A. Gaev, and shipbuilding engineer A.A. Kartikovskii came up with a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(фамилия, имя, отчество)
29 июня 41 г.
дата выдачи пропуска
при утере НЕМЕДЛЕННО сообщается коменданту ШКБФ

Figure 4. Pass for Professor Anatolii Petrovich Aleksandrov to headquarters of Red Banner Baltic Fleet. Archives of National Research Center Kurchatov Institute.

method to make Soviet ships undetectable to magnetic mines. However, implementing this seemingly simple physical idea was so difficult that many mine experts doubted its feasibility. Professional sailors and shipbuilders were well aware of the challenges associated with eliminating the influence of a ship's own magnetic field on compass readings (compass deviation). Success in this area had been achieved a relatively short time before, and only in a small area of the ship where the compass was located.

That is why Academician A.N. Krylov, whom A.F. Ioffe invited to the Leningrad Physical-Technical Institute to discuss ship demagnetization, expressed doubts about the possibility of successfully solving this problem. In his memoirs, A.P. Aleksandrov writes, "I then reported the results of our direct measurements on the ships, about these destroyers that we measured in the dock. I reported on the comparison of the model and full-scale experiments.... It was very important that we immediately understood that magnetic mines can only be sensitive to the vertical component of the magnetic field near the ship. Sensitivity to the horizontal component could only be achieved by very complex, unreliable devices, and therefore, in all our subsequent work, we proceeded from the need to combat changes in the vertical component of the magnetic field. This was correct and was the key to success" [11, p. 9].

A.P. Aleksandrov's laboratory also 'developed a new magnetometer for measuring a ship's magnetic field underwater, which was later called the 'LPTI vertushka.' It was used to measure ships' magnetic fields with an error of ± 1 mOe. Simultaneously, methods for laying out windings on ships and their sectioning, as well as methods for latitudinal and directional regulation of currents in demagnetizing windings, were developed, and a prototype of a 'tracking system' was fabricated, designed for automatic regulation of currents in windings with feedback based on the ship's magnetic field" [13, p. 27].

In the fall of 1938, after full-scale tests on the battleship *Marat* in the Baltic sea, A.P. Aleksandrov presented the results of his work to the USSR Academy of Sciences. "The magnetic field of the largest armored ship in the Soviet fleet was reduced by several dozen times using demagnetizing windings of the 'LPTI system,' and the experiment itself was performed for the first time in the world" [13, p. 30]. A subsequent series of tests in the summers of 1939 and 1940 confirmed the correctness of the chosen demagnetization methods.

"In the fall of 1940, LPTI scientists inspected the Danish cable-laying vessel *Kabel*, equipped with a similar, but significantly less sophisticated, protective device. Denmark offered to sell its 'secret' of the protective system to the USSR, but the Soviet government, taking into account the results obtained at the LPTI, refused the purchase" [14, p. 24].

The 'LPTI system' no longer raised any doubts among representatives of the USSR Academy of Sciences or the Navy. Numerous experiments demonstrated the correctness of the chosen method for demagnetizing ships and confirmed the effectiveness of the LPTI protective device. The Main Military Council of the Navy ordered the installation of demagnetizing devices of the 'LPTI system' on all warships in 1941 [15, p. 24].

From the first days of the Great Patriotic War, the task of mine protection for ships became strategic. Navy representatives, scientists, and shipbuilding engineers were dispatched from Moscow and Leningrad to the Baltic and Black Sea Fleets, as well as to other operational fleets (Fig. 4).

When the war began, A.P. Aleksandrov was involved in demagnetizing ships of the Baltic Fleet [16, p. 21]. During the first month, the situation became especially dire on the Black Sea coast, where the Germans laid a large number of magnetic mines near Sevastopol to block Black Sea Fleet ships. Demagnetization work on ships in this strategically important area began on July 1, 1941, immediately upon the arrival of a team of technical specialists (led by I.V. Klimov) in Sevastopol.

Soon, a team from the Leningrad Physical-Technical Institute (P.G. Stepanov, A.R. Regel', Yu.S. Lazurkin, E.E. Lysenko, and K.K. Shcherbo) arrived there. They brought magnetometers and began measuring the magnetic fields of minesweepers already equipped with demagnetizing devices, as well as adjusting these devices.

On August 8, A.P. Aleksandrov and I.V. Kurchatov arrived in Sevastopol. Tests of the 'LPTI system,' assembled according to standard designs, showed that the magnetic fields of even identical ships varied significantly. Therefore, it was necessary to develop winding layouts and sectioning schemes for each ship individually, by preliminarily measuring the magnetic field using a temporary winding [13, p. 78]. A mine testing ground was established in one of Sevastopol's bays for the work.

On August 4, 1941, a group of British naval officers arrived in the city. "A British delegation arrived, specifically to discuss the demagnetization of ships, and they brought

Действ. до „31“ декабря 1941 г.

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Figure 5. Pass for Professor-Consultant of the People's Commissariat of the Navy I.V. Kurchatov to the headquarters of the Navy. Archives of National Research Center Kurchatov Institute.

with them equipment — the very same pistols that we later used. It was a useful acquisition. But as for nonwinding demagnetization, one could ascertain that the British hadn't proceed any further than we had. And perhaps even the opposite. Their instruction manuals contained major errors, which we found. Whether they were deliberate or not is not known, but, in general, they began to act. They were given a boat to demagnetize, which had already been demagnetized before.... And then it was given to the British. They gasped. 'So you have nonwinding demagnetization.' Well, from that time on, this method, first proposed by Ivan Vasil'evich [Klimov], was well underway'' [16, p. 22].

Soon, A.P. Aleksandrov was summoned to the Northern Fleet, where it was necessary to demagnetize ships and icebreakers. I.V. Kurchatov was assigned to lead the Black Sea group (Fig. 5). As early as August 30, 1941, I.V. Kurchatov, together with Yu.S. Lazurkin and B.A. Tkachenko, completed the nonwinding demagnetization of a submarine [13, p. 83].

The nonwinding demagnetization method, first used for the Black Sea Fleet, then for the White Sea and Caspian Flotillas, became widespread in the fall of 1941. The exception was the Baltic sea, where, until the spring of 1942, the nonwinding demagnetization method independently developed by the Baltic group of the LPTI was used [1].

[1] Currently, ships are demagnetized at specified intervals using two methods: nonwinding and winding. The **nonwinding method** requires the presence of a specific coastal structure, namely a control station or a physical field vessel and cables laid on the ground in the testing area. The ship (submarine) enters the testing area and strictly orients itself along a course taking into account the magnetic declination in the given area. Direct current of varying strengths starting from 2000 A passes through the laid cables. As a result, the ship's magnetic field is essentially brought to values of Earth's field in the given latitudinal region. The **winding method** of magnetic field compensation requires the wrapping of a ship (or submarine) with cables. This method is used after the ship has been built, docked, and undergoes major repair and modernization work. Further steps are the same as those for the nonwinding method. The ship itself also has a demagnetization device, including a control system and three windings: directional, batoxal, and latitudinal, which are controlled automatically. The windings are designed to compensate for the effect of the ship's field on Earth's magnetic field, depending on the ship's latitude, course, and other factors affecting magnetic field changes.

Figure 6. Anatoly Robertovich Regel', Yurii Semenovich Lazurkin, and Igor' Vasil'evich Kurchatov, city of Poti, 1941. Archives of National Research Center Kurchatov Institute.

From late August to October 26, 1941, I.V. Kurchatov's team demagnetized more than 50 ships. Together with Yu.S. Lazurkin and A.S. Shevchenko, they studied the effect of torpedoes loaded into a submarine on its magnetic field; moreover, other factors affecting the stability of the magnetic field of a demagnetized submarine were investigated. The SBR-1 nonwinding demagnetization station ''became not only a technical site for demagnetization, but also an experimental base for scientific work. Simultaneously with work on protecting ships, Kurchatov read lectures to sailors on the theory and practice of demagnetization at the headquarters of the Black Sea Fleet'' [13, p. 83].

On October 29, 1941, a state of siege was declared in Sevastopol. I.Ya. Stetsenko, the head of the Technical Department of the Navy, ordered the relocation of the Black Sea group and all stations (SBR) to the Caucasus coast (Poti and Tuapse). Here, LPTI scientists headed by I.V. Kurchatov trained a group of specialists from the Navy, and equipped stations for demagnetizing ships (Fig. 6).

On December 30, 1941, A.F. Ioffe summoned Kurchatov to Kazan. The work of A.P. Aleksandrov's laboratory on further improving demagnetization methods continued. The primary objective was to ensure the safety of transportation of oil products and military cargo across the Caspian Sea and the Volga Military Flotilla. Consequently, in early 1942, the Caspian and then the Volga Ship Demagnetization Groups were organized. The Shipbuilding Directorate of the People's Commissariat of the Navy of the Soviet Union adopted the ''Regulations on the Organization of Ship Demagnetization Services.'' Furthermore, given the constant threat of attack

Figure 7. A.P. Aleksandrov with Admirals A.A. Sarkisov and P.G. Kotov (left) on Monument unveiling ceremony, city of Sevastopol, 1976.

from Japan, in the spring of 1942, Navy and LPTI specialists were dispatched to Khabarovsk to organize demagnetization services for ships of the Pacific Fleet and the Amur Red Banner Military Flotilla.

In July 1942, Anatolii Aleksandrov was sent to Stalingrad. Because the city was under constant bombing, demagnetizers were forced to hide in a drain pipe that led to the Volga. In less than a month, scientists launched work on the demagnetization of the Volga Flotilla's ships. V.R. Regel', a disciple of A.P. Aleksandrov and a participant in this work, wrote, "The effectiveness of demagnetizing the Volga ships and vessels was very high: despite the small distances between the mines lying on the river bottom and the hulls of ships passing over them, there were no instances of demagnetized ships being blown up by noncontact mines, while nondemagnetized ships were blown up" [17, p. 360]. The Germans were ultimately unable to blockade the Volga; navigation on the river resumed in the fall, and Anatolii Petrovich Aleksandrov's group undoubtedly deserves a great deal of credit for this.

New magnetometers were required for demagnetization. "They were developed under the supervision of I.K. Kikoin in 1942 in the Laboratory of Magnetism at the Institute of Metal Physics of the Ural Branch of the USSR Academy of Sciences in Sverdlovsk. By August 1942, a new method of nonwinding demagnetization of ships with a 'deep reversal' of the ship's initial magnetic field had been developed in the LPTI laboratories evacuated to Kazan" [12, p. 42].

On April 16, 1943, A.F. Ioffe chaired a meeting of the Naval Committee under the Presidium of the USSR Academy of Sciences, where A.P. Aleksandrov reported on the work on ship demagnetization. The commission recommended that new ships be designed with a new, 'distributed' system of protection against magnetic mines; that one of the newly built ships be equipped with a distributed system of demagnetizing device windings and that it be tested; and that directional windings be installed on submarines to improve their protection against magnetic mines [14, p. 92].

Thus, during the war and immediately after it, the system of protection of ships against magnetic mines, developed by A.P. Aleksandrov and his colleagues, saved hundreds of sea and river vessels from destruction and thousands of lives. By the Decree of the Council of People's Commissars of the USSR dated April 10, 1942, A.P. Aleksandrov, I.V. Kurchatov, and six other participants in the work were awarded the Stalin Prize of the first degree for the development of effective methods for demagnetizing ships and their practical implementation.

Figure 8. Monument dedicated to demagnetization of Black Sea Fleet ships in 1941. Erected in Holland Bay, city of Sevastopol, in 1976. Archive of National Research Center Kurchatov Institute.

In this matter, I.V. Kurchatov always gave priority to A.P. Aleksandrov. Anatolii Petrovich, already a three-time Hero of Socialist Labor, an academician, director of the Kurchatov Institute, and president of the USSR Academy of Sciences, considered demagnetization to be one of the most important milestones in his life (Figs 7, 8).

5. Physics and intelligence

In the autumn of 1941, the USSR started to receive classified intelligence information about work being carried out in Germany, Great Britain, and the United States to develop an atomic bomb of unprecedented power and destructive force [18].

According to the Chairman of the Russian Historical Society, S.E. Naryshkin, "during the intelligence operation, which was codenamed ENORMOZ (meaning 'enormous'), spies inside the Manhattan project made it possible not only to successfully penetrate the most guarded military and state secrets of the United States, but also, while remaining unexposed, to regularly inform for several years the country's leadership and Soviet scientists, who were working on this problem, about the corresponding work being carried out in Britain, and then in the United States" [19].

L.P. Beria, who was the People's Commissar for Internal Affairs (abbreviated as NKVD) at the time, treated the information received with the utmost care. In the autumn of 1942, based on a detailed report with an analysis of intelligence materials on research conducted abroad on the splitting of the uranium nucleus (the report was prepared by P.M. Fitin, the head of the Intelligence Directorate of the NKVD of the USSR [20, 21]), L.P. Beria compiled a fact sheet for Joseph Stalin, the Chairman of the USSR State Defense Committee [22]. The fact sheet discussed the possibility of using atomic energy for military purposes abroad and the feasibility of organizing this work in the USSR.

Despite the colossal strain on all forces and resources on the battlefronts of the Great Patriotic War, the USSR's leaders heeded the opinions of a number of scientists, supported by intelligence, on the need to resume work on nuclear topics. If, in that autumn of 1942 — the most difficult one for the Soviet Union — the leaders of our country had not made the strategic decision to develop the Atomic Project, just a few years later the USSR would have faced the atomic threat, being unprepared for it. The combined efforts of Soviet scientists and intelligence officers, building on the solid foundation of nuclear physics research established in the pre-war years, were instrumental in countering this threat. This played a decisive role in the rapid and successful development of the Soviet Atomic Project.

After the USSR State Defense Committee issued Directive No. 2352ss "On the Organization of Work on Uranium" on September 28, 1942, the correct selection of a scientific director for the project was crucial. A.F. Ioffe, P.L. Kapitza, and A.I. Alikhanov were considered for the position. For various reasons, they were rejected. Thus, according to the memoirs of V.M. Molotov, who was overseeing the atomic project on behalf of the government at the time, "I was given the task of finding someone who could create an atomic bomb. I summoned Kapitza, an academician. He said we weren't ready for that, and the atomic bomb wasn't a weapon of this war, but a matter for the future.... I had the youngest and still unknown Kurchatov, who was being held back. I summoned him, we talked, and he made a good impression on me" [23, p. 81].

Starting in the fall of 1942, Kurchatov began to become acquainted with several documents funneled through the NKVD's scientific and technical intelligence channels. Based on these documents, he confirmed the reality of the threat of creating atomic weapons and drafted a memo on the need to "widely expand work on the uranium problem in the USSR." On November 27, 1942, he sent V.M. Molotov a report analyzing intelligence materials and proposing ways to organize work on producing atomic weapons in the USSR. Among other things, in this document, Kurchatov proposed (paragraph 6) "for this complex and enormously difficult task to be managed... to establish a special committee under your chairmanship at the State Defense Committee of the USSR, including scientists (Academicians A.F. Ioffe, P.L. Kapitza, and N.N. Semenov)" [24]. The resumption of uranium research in our country in 1942 became crucial to the entire country's history.

During that tense period of the atomic race, physicists and intelligence officers found themselves in the same force field. They solved a common, incredibly complex problem in different ways. Intelligence information without additional calculations and proof from our physicists would have been useless. The information obtained from intelligence proved important in choosing the direction of our research, and in some matters, it saved us from mistakes. Most importantly, these data saved effort and resources, reducing the time needed for the creation of the Soviet atomic bomb by approximately a year. Certainly, the Atomic Project in the USSR is a successful example of how a state organized the correct interaction of its structures in science and intelligence.

In accordance with State Defense Committee Order No. 2872ss "On Additional Measures in the Organization of Work on Uranium" of February 11, 1943, 40-year-old Professor Igor Vasil'evich Kurchatov became the scientific leader of work on uranium. He was obliged "to conduct the necessary research by July 1, 1943 and submit a report on the possibility of creating a uranium bomb or uranium fuel to the State Defense Committee by July 5, 1943." In addition, an order was adopted "to make Comrades M.G. Pervukhin and S.V. Kaftanov responsible for the day-to-day monitoring of work on uranium and to provide systematic assistance to the special laboratory of the atomic nucleus of the USSR Academy of Sciences." Moreover, "the Presidium of the USSR Academy of Sciences was authorized to transfer a group of researchers from the special laboratory of the atomic nucleus from the city of Kazan to the city of Moscow to carry out the most important part of the work on uranium" [3].

As early as early March 1943, Kurchatov held his first meeting in Moscow, attended by A.I. Alikhanov, Ya.B. Zel'dovich, I.K. Kikoin, G.N. Flerov, and Yu.B. Khariton. During the first months of Laboratory No. 2, Kurchatov outlined the main work plan: building a reactor (uranium-graphite or heavy water), choosing a method for separating uranium isotopes by diffusion or electromagnetic means, and searching for the optimal bomb design. All of this work was proceeding simultaneously:

— the creation of a nuclear reactor using natural uranium and ordinary water (G.N. Flerov, V.A. Davidenko);

— development of a nuclear reactor using natural uranium and graphite (I.V. Kurchatov, I.S. Panasyuk);

— development of a nuclear reactor using natural uranium and heavy water (A.I. Alikhanov, S.Ya. Nikitin);

— development of a cyclotron (I.V. Kurchatov, L.M. Nemenov);

— separation of natural uranium isotopes (I.K. Kikoin, L.A. Artsimovich);

— development of the chemistry of transuranic elements and its practical application (B.V. Kurchatov);

— physical research aimed at creating a uranium industry for the production of optimal fuel elements for nuclear reactors (I.V. Kurchatov, I.S. Panasyuk);

— physicochemical research aimed at organizing the industrial production of optimal graphite blocks for nuclear reactors (I.V. Kurchatov, I.S. Panasyuk, N.F. Pravdyuk, V.V. Goncharov);

— physicochemical research aimed at developing an industrial technology for producing heavy water for nuclear reactors (A.I. Alikhanov, R.L. Serdyuk, D.M. Samoilovich, M.I. Kornfeld); and

— measurement of nuclear constants and neutron physics (P.E. Spivak, I.S. Panasyuk, S.A. Baranov, M.I. Pevzner).

To begin the work, I.V. Kurchatov had one gram of radium, 20 kg of uranium, 500 kg of nonferrous metals, 6 tons of steel, two lathes, 30,000 rubles, 10 apartments, and 500 m^2 of space [1]. At the same time, in the United States, thousands of workers, engineers, and scientists, many of whom were European emigrants fleeing fascism to the United States, were involved in the Manhattan Project.

On July 30, 1943, I.V. Kurchatov wrote a memorandum to the Deputy Chairman of the USSR State Defense Committee, V.M. Molotov, reporting on the work of Laboratory No. 2; the memo also contained an analysis of the current state of the uranium problem and prospects for further development of the work. He asked for permission to involve the country's scientists in research, and spoke of the need to accumulate 100 tons of uranium in the USSR in 1944–1945, to produce uranium-235 in 1945, and to accumulate 2–3 tons of heavy water in 1946. In his opinion, in addition to intensifying work on the exploration of uranium deposits, it was necessary to begin construction of a plant in Chirchik (Uzbek SSR), design a 20-stage diffusion machine, and build a plant with a capacity of 300 kg of uranium hexafluoride (a raw material for uranium isotope separation plants) per day [25].

In the spring of 1944, I.V. Kurchatov sent another memorandum on the results of Laboratory No. 2's work for August 1943–February 1944 [26]. He wrote that the Laboratory had completed theoretical research, and that uranium raw materials were now essential for moving on to practical work.

On April 8, 1944, the State Defense Committee issued Resolution No. 5582ss, "On Measures for Organizing the Work of the USSR Academy of Sciences Laboratory and the Production of Heavy Water and Uranium" [26]. The resolution approved the Laboratory's work plan for 1944, schedule, and funding from the reserve fund of the Council of People's Commissars of the USSR in the amount of 4 million rubles for 1944.

At the same time, the People's Commissariat of Nonferrous Metallurgy was to ensure the production of 500 kg of metallic uranium at a pilot plant in 1944, supply Laboratory No. 2 with tens of tons of high-quality graphite blocks, and build a workshop for the production of metallic uranium by January 1, 1945.

6. Laboratory No. 2. The beginning

In the spring of 1944, the scientists from the Laboratory settled on the outskirts of Moscow — in the Pokrovskoe-Streshnevo district, where Kurchatov had received land use rights to a 20.5-hectare plot containing several buildings erected before the war for the All-Union Institute of Experimental Medicine [27]. By the fall of 1944, the number of researchers at Laboratory No. 2 had increased, and the pace of work had also accelerated (Fig. 9).

A crucial step was the launch of the cyclotron. Its construction was supervised by L.M. Nemenov, who, together with P.Ya. Glazunov, immediately after the military blockade of the city of Leningrad was lifted, transported a high-frequency generator, some equipment, and materials from the LPTI cyclotron — its construction was completed on June 22, 1941 — along the legendary 'Road to Victory' railway (Figs 10, 11).

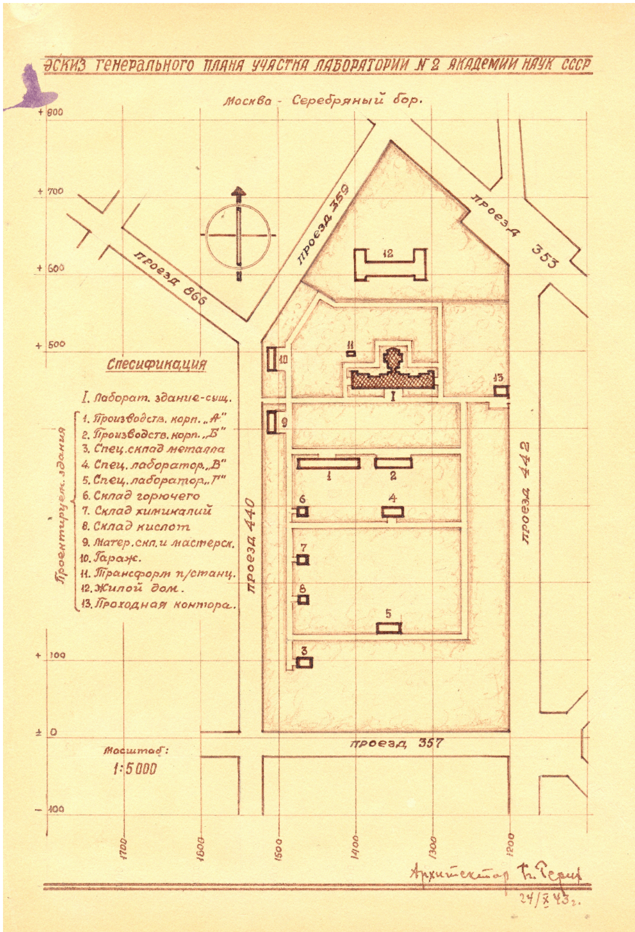
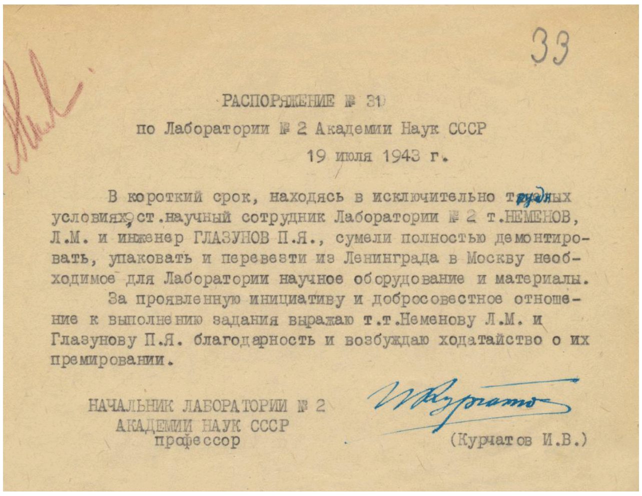


Figure 9. Sketch of general plan for Laboratory No. 2 of USSR Academy of Sciences, 1943. Archive of National Research Center Kurchatov Institute. F.2. Op.1. D.69\39. L.1.



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РАСПОРЯЖЕНИЕ № 31
по Лаборатории № 2 Академии Наук СССР
19 июля 1943 г.

В короткий срок, находясь в исключительно трудных условиях, ст. научный сотрудник Лаборатории № 2 т. НЕМЕНОВ, Л.М. и инженер ГЛАЗУНОВ П.Я., сумели полностью демонтировать, упаковать и перевезти из Ленинграда в Москву необходимое для Лаборатории научное оборудование и материалы.

За проявленную инициативу и добросовестное отношение к выполнению задания выражаю т.т. Неменову Л.М. и Глазунову П.Я. благодарность и возбуждаю ходатайство о их премировании.

НАЧАЛЬНИК ЛАБОРАТОРИИ № 2
АКАДЕМИИ НАУК СССР
профессор (Курчатов И.В.)

Figure 10. Order No. 31 for Laboratory No. 2 of USSR Academy of Sciences, July 19, 1943. Archives of National Research Center Kurchatov Institute. F.1. Op. 1ls. D.1. L.33.

In order to recognize the outstanding contribution of Leonid Mikhailovich Nemenov and electrical engineer Petr Yakovlevich Glazunov, Order No. 31 was issued for Laboratory No. 2 of the USSR Academy of Sciences on July 19, 1943: "In a short period of time, under exceptionally difficult conditions, senior research fellow of Laboratory No. 2,

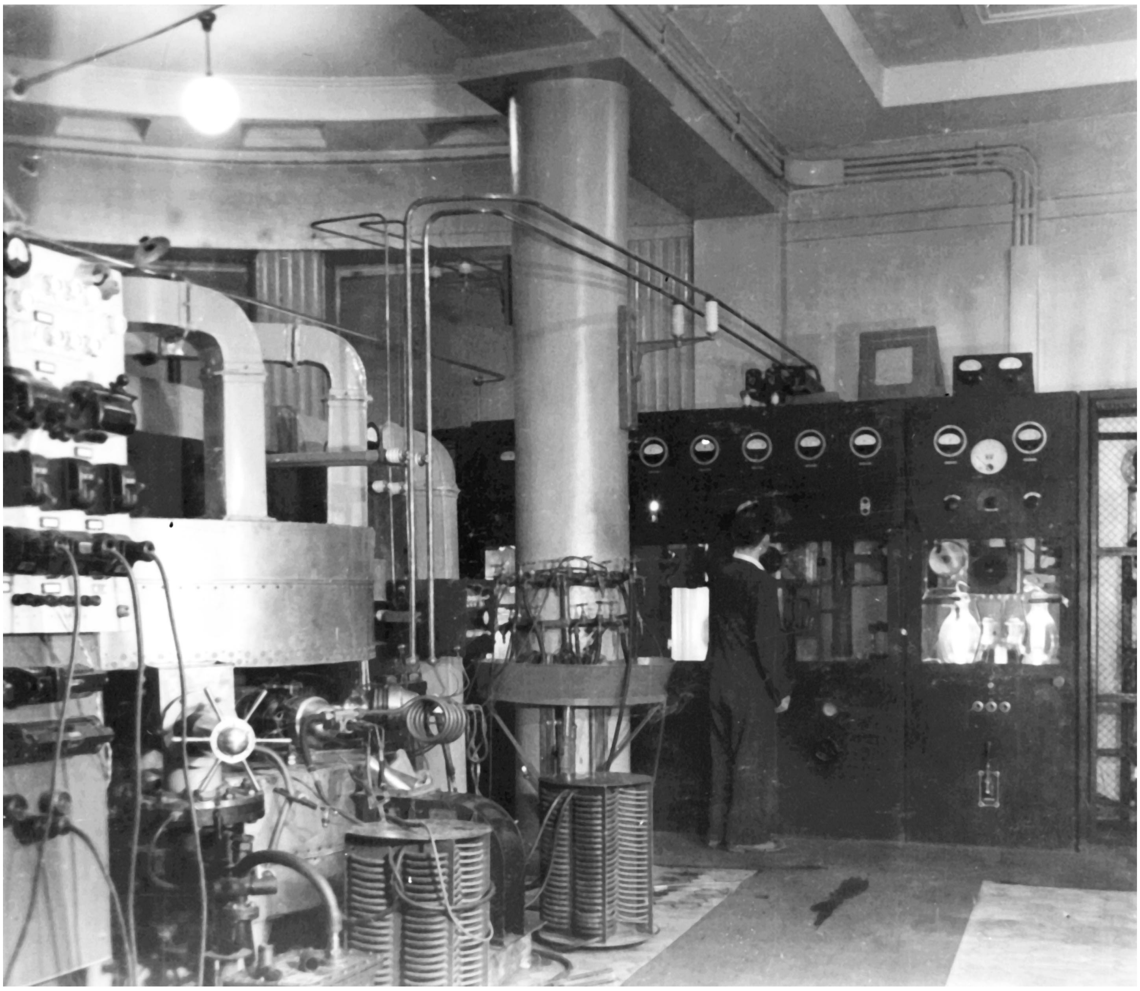


Figure 11. M-1 cyclotron in Laboratory No. 2 of USSR Academy of Sciences, 1944. Archives of National Research Center Kurchatov Institute. F.1. Op. 1nd. D.397. L.17.

Comrade L.M. Nemenov and engineer P.Ya. Glazunov, managed to completely dismantle, pack, and transport the scientific equipment and materials necessary for the laboratory from Leningrad to Moscow. For their initiative and conscientious attitude to the fulfillment of the task, I express my gratitude to Comrades L.M. Nemenov and P.Ya. Glazunov and I am putting in for their bonus payments'' (Head of Laboratory No. 2 of the USSR Academy of Sciences, Professor I.V. Kurchatov).

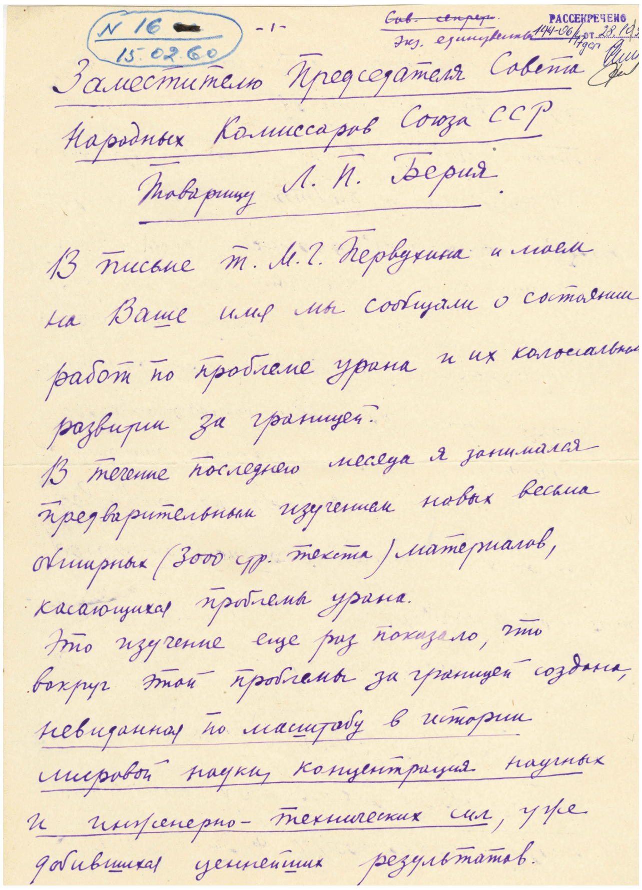
The cyclotron was installed on the ground floor of the main building of the laboratory; the facility was codenamed 'M-1.' On September 25, 1944, the cyclotron in Laboratory No. 2 was commissioned. This enabled the accumulation of tracer quantities of plutonium — the base metal for nuclear warheads — by irradiating uranium with neutrons. Boris Vasil'evich Kurchatov began studying its nuclear and chemical properties and developed the first recommendations for an industrial technology for separating plutonium from uranium and fission fragments.

The development of the Soviet Atomic Project was gaining momentum. In fact, the USSR State Defense Committee made a key decision, by issuing Resolution No. 7069ss, ''On Urgent Measures to Ensure the Deployment of Work Conducted by Laboratory No. 2 of the USSR Academy of Sciences'' as of December 3, 1944. According to this document, all work on the project was concentrated in Moscow, where land was allocated for the construction of buildings for Laboratory No. 2 of the USSR Academy of Sciences. The State Defense Committee also decreed ''to assign to Comrade L.P. Beria the responsibility for overseeing the development of uranium work.'' According to L.D. Ryabev, the last Minister of Medium Machine Building of the USSR, ''the beginning of December 1944 can be considered a turning point in the fate of the atomic project — Beria took control of the program into his own hands'' [28, p. 36].

An objective assessment of L.P. Beria's contribution to the development of the Soviet Atomic Project remains to be seen. The appointment of Igor' Vasil'evich Kurchatov as scientific director and Lavrentii Pavlovich Beria as government curator — a tandem that formed despite their different backgrounds, educations, personalities, and direct access to Joseph Stalin — led our country to the successful completion of the Atomic Energy Project in the shortest possible time (Fig. 12).

A similar interaction among the country's leadership, scientists led by J.R. Oppenheimer, and the military through Brigadier General L. Groves existed in the United States as part of the Manhattan Project, which by 1945 was already in the final stretch. Just over six months remained before the detonation of the world's first atomic bomb at the Alamogordo test range in the United States.

The Third Reich had effectively withdrawn from the atomic race at that point, although the Germans had the best starting position in the project's development. By the late 1930s, German physicists had made the most progress in the then-



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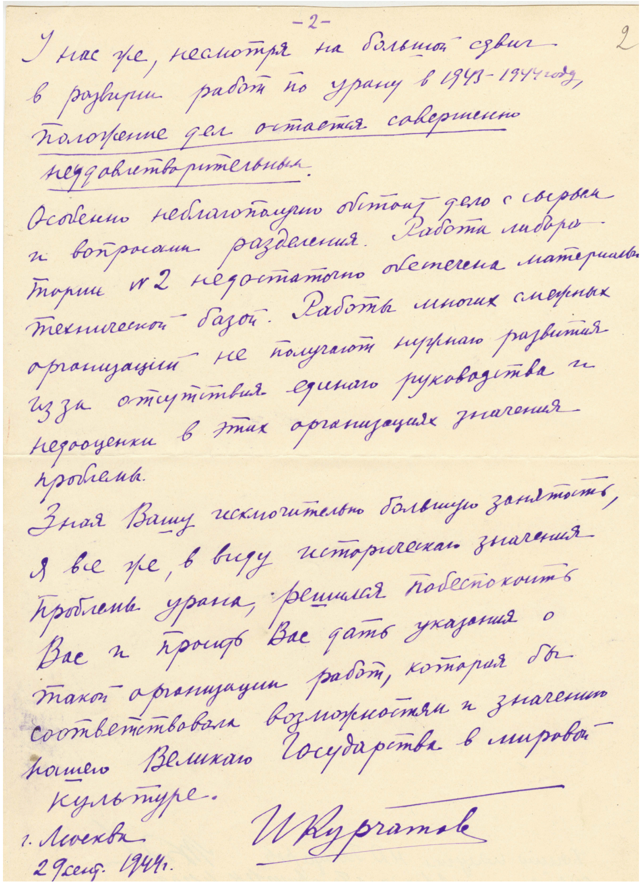
Экз. единственный
РАССЕКРЕЧЕНО 144-06/47 от 28.10

Заместителю Председателя Совета
Народных Комиссаров Союза ССР
Товарищу Л. П. Берия.

В письме т. М. Г. Первухина и моем на Ваше имя мы сообщали о состоянии работ по проблеме урана и их колоссальном развитии за границей.

В течение последнего месяца я занимался предварительным изучением новых весьма обширных (3000 стр. текста) материалов, касающихся проблемы урана.

Это изучение еще раз показало, что вокруг этой проблемы за границей создана невиданная по масштабу в истории мировой науки концентрация научных и инженерно-технических сил, уже добившихся ценнейших результатов.



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У нас же, несмотря на большой сдвиг в развитии работ по урану в 1943-1944 году, положение дел остается совершенно неудовлетворительным.

Особенно неблагополучно обстоит дело с сырьем и вопросами разделения. Работа Лаборатории №2 недостаточно обеспечена материально-технической базой. Работы многих смежных организаций не получают нужного развития из-за отсутствия единого руководства и недооценки в этих организациях значения проблемы.

Зная Вашу исключительно большую занятость, я все же, в виду исторического значения проблемы урана, решился побеспокоить Вас и просить Вас дать указания о такой организации работ, которая бы соответствовала возможностям и значению нашего Великого Государства в мировой культуре.

г. Москва
29 сент. 1944.

И. Курчатов

No. 16 — top Secret — DECLASSIFIED
February 15, 1960 — single copy — 144-06/47, agreement dated October 28

To the Deputy Chairman
of the Council of People's Commissars of the USSR
Comrade L.P. Beria.

In the letter from Comrade M.G. Pervukhin and myself addressed to you, we report on the state of work on the uranium problem and its colossal development abroad.

Over the past month, I have been engaged in a preliminary study of new, very extensive (3000 pages of text) materials concerning the uranium problem.

This study has once again demonstrated that a concentration of scientific and engineering resources, unprecedented in the history of world science, has been created around this problem abroad, and that they have already achieved extremely valuable results.

Despite the significant advances in uranium research in 1943–1944, the situation here remains completely unsatisfactory.

The situation is particularly unfavorable with raw materials and separation issues. Laboratory No. 2 is inadequately supported by the necessary technical resources. The work of many related organizations is not progressing due to the lack of unified leadership and their underestimation of the problem's significance.

Knowing your exceptionally busy schedule, I nevertheless, in view of the historical significance of the uranium problem, have decided to contact you and ask you for instructions on organizing the work in a manner consistent with the capabilities and significance of our Great State in world culture.

Moscow,
September 29, 1944 — I. Kurchatov

Figure 12. Facsimile reproduction of report from I.V. Kurchatov to Deputy Chairman of Council of People's Commissars of USSR, Comrade L.P. Beria, September 29, 1944. Archive of Kurchatov Institute Research Center. F.2, Op.1, D.63, L.1-2.

new field of nuclear physics. The German physics school had traditionally been considered the strongest in the 1920s and 1930s: a galaxy of outstanding scientists and a number of Nobel Prizes awarded for truly important discoveries in physics and chemistry. In September 1939, a meeting was held at the Kaiser Wilhelm Institute for Physics, which resulted in the launch of the Uranium Project. Twenty-two scientific institutes planned to participate in its implementation. Such eminent German scientists as W. Heisenberg, W. Bothe, G. Geiger, K. Weizsäcker, and others were involved in the project.

Heisenberg and Bothe began theoretical work on the reactor, and, by the end of 1939, Heisenberg's report discussed the feasibility of technically generating energy through uranium fission. Two reactor types — uranium-graphite and heavy-water — were simultaneously considered. Germany had the primary resources for this: in 1939, it occupied Czechoslovakia with its uranium mines in Jáchymov; in 1940, it occupied Belgium, which possessed over 1000 tons of uranium concentrate; and finally, it occupied Norway, with its heavy-water plant. In the summer of 1940, construction of a heavy-water reactor began on the grounds of the Physics Institute in Berlin. However, in 1942, progress began to stall, and by 1943, the German Uranium Project had effectively been sidelined. There were a number of different reasons for this, ranging from the global war on two fronts to personal disagreements among the project participants. However, the main reasons for the inglorious end of the German Uranium Project were the wrong choice of strategic priorities and the overall ineffective organization and management of the processes.

7. Turning point in development of Soviet Atomic Project

The year 1945 marked a significant milestone in the history of the Soviet Atomic Project. In July 1945, during the Potsdam Conference of Allied leaders, the United States tested its first atomic bomb. This event was timed specifically for the meeting of the leaders in order to put pressure on Joseph Stalin. On August 6 and 9, the United States detonated atomic bombs over the two Japanese cities of Hiroshima and Nagasaki, thereby conducting the world's first human test of an atomic bomb, which killed more than 200,000 residents of these cities. Thus, the atomic bomb became the weapon of World War II.

It was obvious to the Soviet leaders that our country would most likely become the next target for the United States. It was imperative to expedite all work on the creation of Soviet atomic weapons. On August 20, 1945, State Defense Committee Resolution No. 9887ss/ov established a Special Committee Under the State Defense Committee to "monitor all work on the use of intra-atomic energy from uranium" [29].

The First Main Directorate (PGU) under the Council of Ministers of the USSR, headed by B.L. Vannikov, was subordinate to the Special Committee. A Technical Council was established within the PGU, which included I.V. Kurchatov, Yu.B. Khariton, A.I. Alikhanov, A.I. Voznesensky, A.F. Ioffe, P.L. Kapitza, I.K. Kikoin, V.G. Khlopin, ministers of the responsible industries, and heads of the later-established design bureaus and nuclear industry plants. It was necessary to ensure geological exploration and mining of uranium, organize a new metallurgy industry from scratch, and establish the production of high-purity graphite within the shortest possible time. I.V. Kurchatov received almost unlimited powers to organize the work.

According to E.P. Velikhov, "When one reads the minutes of the Special Committee of the State Defense Committee, it is obvious that its meetings are nothing more than working meetings. Igor' Vasil'evich says what needs to be done, and Beria translates this into the corresponding state orders. Never before, nor ever since, in world history has the government so completely handed over the reins of power to scientists..." [30, p. 12].

As early as April 1945, I.V. Kurchatov reported to L.P. Beria on four main areas of work: a uranium-graphite reactor, a diffusion plant for producing uranium-235, heavy water for a uranium-heavy-water pile for plutonium production, and, finally, bomb construction.

Experimental studies and an analysis of industrial capabilities showed that uranium-graphite reactors could enable industrial production of plutonium a year earlier than heavy-water reactors. This year could have been decisive, since, according to the plans for the atomic bombing of the USSR, they were scheduled for 1950, and any delay would have been fatal for our country. Despite serious debates over the choice of reactor type, primarily with A.I. Alikhanov, who advocated the heavy-water reactor, I.V. Kurchatov insisted on his own. Finally, the PGU prioritized the construction of a physical prototype of a uranium-graphite pile as a physical facility to confirm the fundamental feasibility of a chain reaction using natural uranium.

I.V. Kurchatov formulated the main objectives for the start of construction: developing a detailed reactor theory, and producing hundreds of tons of high-purity graphite and tens of tons of ultra-pure (impurity-free) uranium. There had not yet been any experience in constructing such complex facilities as a nuclear reactor.

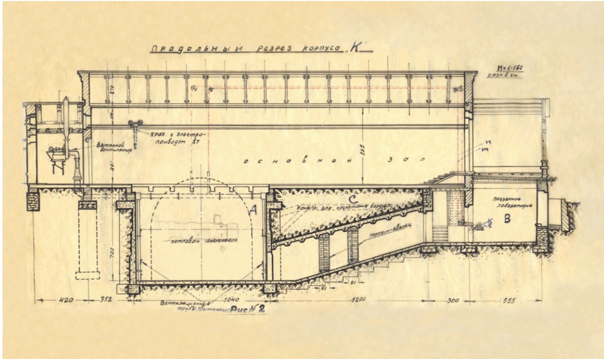

Figure 13. Drawing of Building K. Archives of National Research Center Kurchatov Institute. F.1. Op.1nd. D.26a. L.13.

As early as June 1, 1946, I.V. Kurchatov presented a construction schedule for an experimental uranium-graphite reactor, encoded 'F-1' (Physical First). The Akademproekt workshop, headed by architect A.V. Shchusev, was assigned the task of designing the building for the first reactor (Fig. 13).

Numerous academic and departmental research institutes, design bureaus, and enterprises participated in the construction of the F-1 reactor, and then the next one — an industrial reactor in the Urals. Secrecy throughout the country was maintained at the highest level. Until the detonation of the first Soviet bomb in August 1949, foreign intelligence agencies predicted that our country would not be able to develop a nuclear weapon before 1955.

Starting in the summer of 1946, scientists at Laboratory No. 2 conducted experiments, studied the characteristics of uranium blocks, and selected their optimal dimensions — all of this took place in a large army tent on the Laboratory grounds. From the beginning of August to November 1946, Kurchatov and his colleagues assembled, examined, and disassembled gradually increasing models of the reactor [31] (Fig. 14).

Four hundred fifty tons of graphite and nearly fifty tons of uranium were used. Igor' Vasil'evich Kurchatov personally supervised all the work. Four models had to be assembled, examined, and disassembled. The fifth became the operating F-1 reactor; its construction began on November 15, 1946.

The reactor consisted of a sphere made of a uranium-graphite lattice, graphite, remotely actuated cadmium control rods, experimental channels, and wells placed below ground level for protection from radiation (Fig. 15).

All work was carried out in strict secrecy. In documents, the facility was referred to as the 'assembly workshop' or 'Building K' (the 'Kurchatov' building). According to the recollections of Laboratory No. 2 researchers, a special encryption system was used: the pile was called an 'electrolyzer,' the word 'uranium' was replaced by 'silicon,' and all reactor assembly workers, the youngest of whom was only 15 years old, signed a nondisclosure agreement before startup.

On December 25, 1946, at 2:00 PM, the final 62nd layer of the reactor core was laid. Kurchatov himself sat at the pile control panel and began removing cadmium rods from the core. When the heat output in the pile reached several ten watts, he stabilized the process and, using the emergency

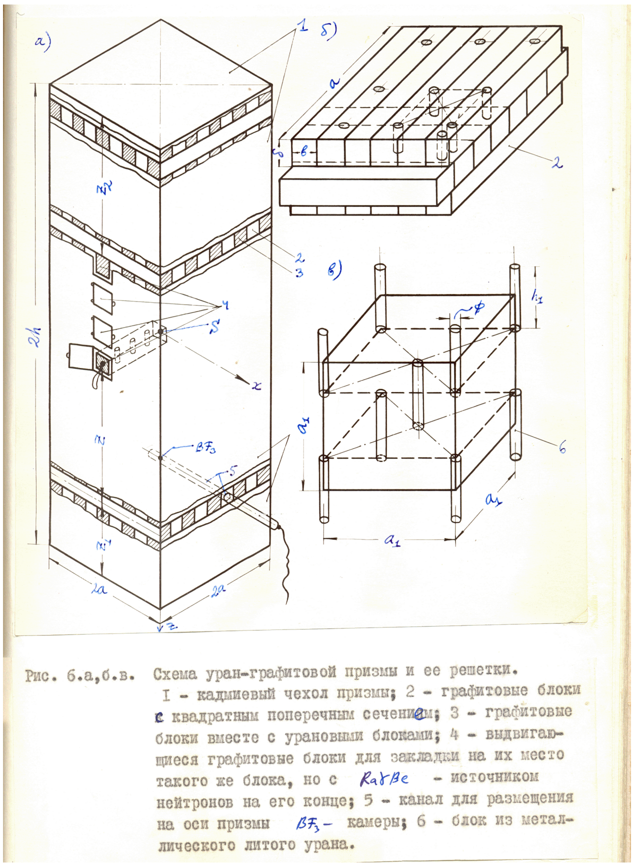

Figure 14. Page from I.V. Kurchatov's and I.S. Panasyuk's scientific report, "First Soviet Atomic Reactor." Diagram of uranium-graphite prism and its lattice. Archives of National Research Center Kurchatov Institute. F.1. Op.1nd. D.2566. L.22.

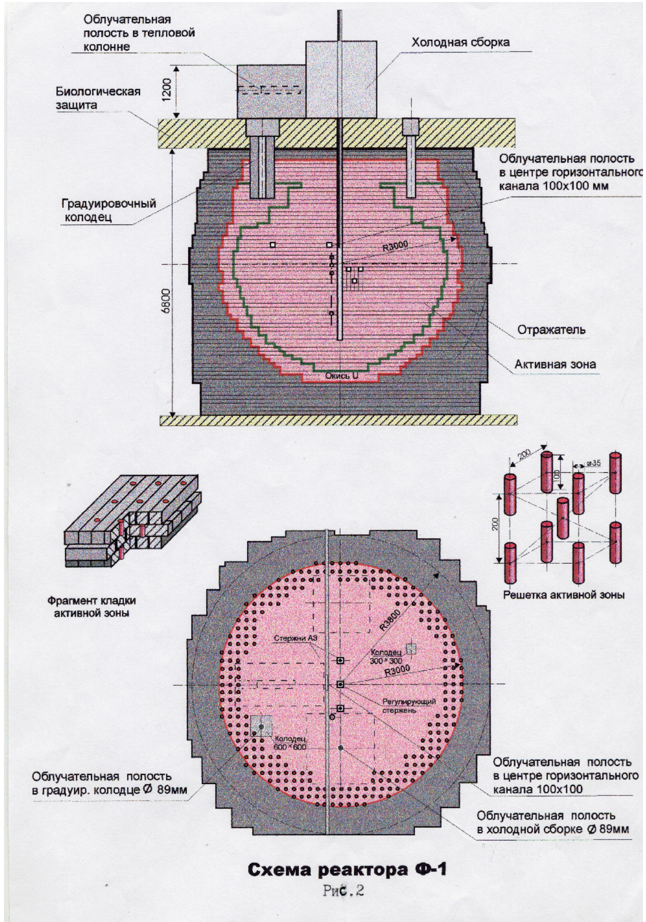

Figure 15. Schematic of F-1 reactor.

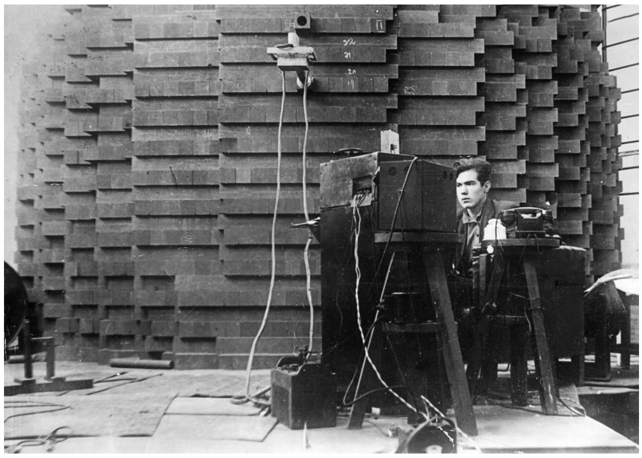

Figure 16. Physicist on duty at F-1. Archives of National Research Center Kurchatov Institute. F.1. Op.1. D.31. L.14.

protection rod, shut down the reaction. At 6:00 PM, for the first time in Eurasia, under the direction of I.V. Kurchatov, a controlled self-sustaining uranium fission chain reaction was achieved. During that first startup, the reactor operated for approximately four hours.

The next day, L.P. Beria arrived at Laboratory No. 2, and Kurchatov demonstrated to him a controlled chain reaction. Three days later, the country's leaders were informed, "With the help of the constructed uranium-graphite pile, we are now able to solve the most important issues and problems concerning the industrial production and use of atomic energy" [32].

8. From first F-1 reactor to first atomic bomb

It is difficult to overstate the significance of the construction of the F-1 reactor in 16 months in a ruined post-war country. After all, the launch of the F-1 reactor became a crucial milestone in the development of Soviet atomic weapons, confirming the feasibility of a self-sustaining nuclear chain reaction, but, most importantly, demonstrating the complete self-sufficiency of Soviet science and industry in the fundamentally new nuclear project.

In 2016, the National Research Center Kurchatov Institute opened an exhibition in the F-1 reactor building. Visitors have a unique opportunity to see the first nuclear reactor, learn about its history, and literally touch the history of the legendary Soviet nuclear project.

From December 25, 1946, work on the F-1 reactor continued 24/7 (Fig. 16). The reactor was periodically accelerated to relatively high power levels, which was necessary for the accumulation of plutonium and for testing materials under radiation.

These efforts accelerated the development of the A-1 industrial uranium-graphite reactor in the Urals — the famous 'Annushka' reactor for the industrial-scale production of plutonium, the core for the first Soviet atomic bomb. Its development began in Laboratory No. 2 in the spring of

1945. Even though the decisive experiment on the F-1 reactor had not yet been conducted, I.V. Kurchatov believed it was essential to begin designing an industrial reactor immediately. In the summer of 1945, Kurchatov selected its design — a water-cooled uranium-graphite pile, which, for secrecy reasons, was codenamed 'Apparatus A.' I.V. Kurchatov was appointed scientific director of the project, N.A. Dollezhal was appointed chief designer of the industrial reactor, and V.I. Merkin was appointed chief technologist of the project.

The site for the construction of Plant No. 817 (Facility A, a branch of Laboratory No. 2, was known in documents) was chosen in the Chelyabinsk region on the shore of Lake Kyzyl-Tash and secured by a Decree of the USSR Council of People's Commissars in December 1945 [33]. Its territory met all the requirements: the presence of a large amount of water for cooling the reactor, power lines and railways, and remoteness from the central part of the country. Three plants were to be built: 'A', reactor 'A'; 'B', a radiochemical complex for extracting plutonium from irradiated uranium; and 'V', a chemical metallurgical plant for manufacturing the bomb. Construction of a future secret city of nuclear scientists, Ozersk, began simultaneously.

The successful commissioning of the F-1 reactor in Moscow in December 1946 confirmed the correctness of I.V. Kurchatov's priorities. Construction proceeded at a record pace. In December 1947, micrograms of plutonium solution were obtained in Z.V. Ershova's laboratory at Research Institute No. 9 and handed over to I.V. Kurchatov for nuclear physics measurements. In the summer of 1948, the Radium Institute team, led by V.G. Khlopin, developed a technology for the industrial extraction of plutonium from uranium irradiated in the reactor at Plant 'B', the radiochemical plant, and, under the direction of A.A. Bochvar, its metallurgy at Plant 'V', the chemical-metallurgical plant, where the extracted plutonium was purified and processed into bomb metal.

From June 18 to 22, 1948, the USSR's first industrial reactor for producing weapons-grade plutonium reached its design capacity. On December 22, 1948, Radiochemical Plant 'B' for the separation of weapons-grade plutonium was commissioned, and in February 1949, Chemical Metallurgical Plant 'V' was commissioned. The required amount of plutonium for the first Soviet atomic bomb was produced by mid-1949, and, in August, all the components of the bomb were manufactured from high-purity metallic plutonium at Plant V [34, p. 143].

To create the atomic bomb itself, in 1946, by a decree of the Council of Ministers of the USSR, a branch of Laboratory No. 2 was organized — design bureau KB-11, with P.M. Zernov and Yu.B. Khariton appointed director and chief designer, respectively. A year later, KB-11 expanded its operations to the village of Sarov in the Nizhny Novgorod region. All work was conducted under the scientific supervision of Laboratory No. 2.

In the summer of 1949, work on the first Soviet atomic bomb, the RDS-1 (abbreviation for Special Jet Engine was used as a cover name), was completed. The issue of constructing a testing ground for the atomic bomb, as well as for the purpose of "investigating the destructive effect of the device on living organisms using various experimental animals," was considered by the Special Committee under the Council of Ministers of the USSR on November 11, 1946 [35]. A.P. Zavenyagin was to submit proposals by December 1, 1946, regarding the location and construction timeframe for the test site, the candidacy of its director, and construction support measures.

Figure 17. I.V. Kurchatov at Semipalatinsk test site, August 1949. Archive of National Research Center Kurchatov Institute.

The Semipalatinsk test site in the Kazakh SSR is a stretch of desert steppe, far from populated areas. Tunnels and runways were built here, and prototype tanks, rocket launchers, and aircraft were deployed. The delivery of the bomb to the test site by rail was supervised by A.P. Zavenyagin, who accompanied 'Product No. 1' throughout its entire journey. A 37.5-meter-tall metal tower was erected in the center of the site, to which the RDS-1 bomb was secured.

A special decree of the Special Committee determined the date and personnel responsible for the tests: "August 29–30, 1949, at Test Site No. 2.... Appoint Academician Kurchatov as the scientific director, and Yu.B. Khariton as the deputy scientific director (for design and scientific matters)" [36].

On August 29, 1949, at 4:00 AM Moscow time, 170 km west of Semipalatinsk, the atomic bomb detonated, exceptional in its destructive power (Fig. 17).

On August 30, a report was sent to the head of the Soviet state, "We report to you, Comrade Stalin, that through the efforts of a large team and four years of intense work, your task of creating a Soviet atomic bomb has been completed.... The atomic explosion was recorded using special instruments, as well as by observations of a large group of scientists, military personnel, and other specialists, and by the members of the Special Committee directly involved in the test: Comrades Beria, Kurchatov, Pervukhin, Zavenyagin, and Makhnev" [37].

An American reconnaissance aircraft with a special laboratory on board recorded elevated levels of radiation in the atmosphere. Thus, the West learned that an atomic bomb had been detonated in the USSR, and this was a real shock for politicians and the military. The successful test of the first Soviet atomic bomb changed the world balance: the United States lost its main advantage, which it had enjoyed for four years after the end of World War II.

9. Conclusions

Thus, under the scientific leadership of I.V. Kurchatov, the country's nuclear shield was forged. Laboratory No. 2, in its first six years of existence, accomplished the strategic task set by the country's leaders.

By a secret Decree of the USSR Council of Ministers dated October 29, 1949, signed by Joseph Stalin, 843 participants in the Soviet Atomic Project were awarded the Order of Lenin (262), the Order of the Red Banner of Labor (496), and the Order of the Badge of Honor (52). By a decree of the Presidium of the Supreme Soviet of the USSR, 33 participants in the Soviet Atomic Project were awarded the title Hero of Socialist Labor.

A large number of institutes, laboratories, and enterprises across the USSR participated in the Atomic Project. In the war-ravaged country, new industries were organized, new branches of nuclear engineering and instrument making were established, and the Ministry of Medium Machine Building, the predecessor of Rosatom, was founded. The Soviet Atomic Project gave birth to nuclear energy, nuclear medicine, new materials science, information technology, accelerator technologies, and radiobiology.

We managed not only to catch up with the United States in the military race but also to surpass them, creating the hydrogen bomb in 1953. Then, within the next few years, we became the pioneers of peaceful nuclear energy, controlled thermonuclear fusion, and a nuclear icebreaker fleet.

Soviet scientists managed to strengthen the strategic priority by creating the atomic bomb, establishing nuclear parity in the world for many decades. Thanks to the success of the Soviet Atomic Project, our country not only survived as a sovereign state but also transformed the face of civilization. As a result, almost all the main branches of the scientific and technological complex were established, shaping the USSR's new geopolitical status as a global superpower. These branches continue to ensure national security and the stable position of the Russian Federation among global technological leaders.

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