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# Moscow State University physics alumni and the Soviet Atomic Project

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## Contents



**Abstract. In this paper, two closely related themes are addressed: (1) the role that M V Lomonosov Moscow State University (MSU) played in training specialists in physics for the Soviet Atomic Project, and (2) what its alumni contributed to the development of thermonuclear weapons. In its earlier stages, the Soviet Atomic Project was in acute need of qualified personnel, without whom building nuclear and thermonuclear weapons would be an impossible task, and MSU became a key higher educational institution grappled with the training problem. The first part of the paper discusses the efforts of the leading Soviet scientists and leaders of FMD (First Main Directorate) to organize the training of specialists in nuclear physics at the MSU Physics Department and, on the other hand, to create a new Physics and Technology Department at the university. As a result, a number of Soviet Government's resolutions were prepared and issued, part of which are presented in the paper and give an idea of the large-scale challenges this sphere of education was facing at the time. Information is presented for the first time on the early MSU Physics Department graduates in the structure of matter, being employed in the FMD organizations and enterprises from 1948 to 1951. The second part discusses the contribution to the development of thermonuclear weapons by the teams of scientists led by Academicians I E Tamm, A N Tikhonov, and I M Frank, and including MSU physics alumni. The paper will be useful to anyone interested in the history of Russian physics.**

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## 1. Introduction

The year 2005 was marked by many memorial observances. The main one was the 60th anniversary of the victory in the Great Patriotic War. Many students and teachers perished during the war defending their motherland and homes. In his staff report on the training of physicists, submitted to Lavrenty P Beria, V P Potemkin (the RSFSR People's Commissar of Education) pointed out that during the war the number of students studying in departments of physics and mathematics, physics, as well as mechanics and mathematics at various higher educational institutions had declined dramatically [1]. At Soviet universities, there were 5891 physics students in 1940, but only 2191 in 1944; in pedagogical institutes there were 8992 physics students in 1940, and only 4371 in 1944. The number of postgraduate students in physics declined from 142 in 1940 to 42 in 1944.

The General Assembly of United Nations declared the year 2005 the International Year of Physics. This was not by accident, since fundamental research by Russian and foreign physicists has an enormous impact on all aspects of life in modern society. The majority of Soviet and Russian Nobel Prize Laureates are physicists. Among those participating in the Soviet Atomic Project were Nobel Prize Winners in Physics P A Cherenkov, I M Frank, V L Ginzburg, P L Kapitza, L D Landau, N N Semenov, and I E Tamm, the Nobel Prize Winner in Peace A D Sakharov, and many other outstanding Soviet scientists.

In 2005, the scientific community celebrated the 250th anniversary of Moscow State University (MSU), the oldest and most prestigious Russian higher educational institution. Ceremonial meetings dedicated to the 250th anniversary of M V Lomonosov MSU were held not only at the university. A meeting of the Scientific and Technical Council of the Russian Federal Nuclear Center 'All-Russian Scientific Research Institute of Experimental Physics (RFYaTs — VNIIEF)' dedicated to this important event was held in June 2005. In his report, the Director of the Center, R Il'kaev, remarked that the staff of RFYaTs — VNIIEF is

comprised of physicists and mathematicians among whom are 250 MSU graduates.

Another event is related to the 60th anniversary of Soviet atomic industry. September 28 is the Annual Day of Workers of the atomic industry, one of the most knowledge-consuming branches of industry. For more than 50 years, MSU has interacted with atomic industry along two lines: (i) educating students to become highly qualified specialists, and (ii) conducting research. In the present article, I have used the results of my work on the archive documents of the former First Main Directorate (FMD) of the USSR Council of Ministers to examine the activity of the Physics Department and Physics and Technology Department of MSU in, chiefly, preparing specialists for the Soviet Atomic Project. I have also given the most important examples of the work done by MSU physics alumni in building nuclear weapons and in developing atomic science and engineering. Of course, I understand that the scope of such a paper is not enough to give a full picture of the events — the study of the history of modern physics should be continued, since this is a multifaceted topic.

It must be noted that the very construction of the new MSU complex of buildings in Sparrow (formerly Lenin) Hills was due to the effort of builders of the Ministry of Middle Engineering Industry (MMEI), who realized the governmental resolution. Their leader A N Komarovskii, who headed Glavpromstroy of the USSR Ministry of Internal Affairs (later the MMEI Glavpromstroy), devoted to this topic a significant chapter titled "Building Moscow State University" in his published reminiscences *Memoirs of a Builder* [2]:

"*In the middle of 1948, I was called in by Nikolai Alekseevich Voznesensky, then Vice Chairman of the USSR Council of Ministers and head of the State Planning Commission. I was assigned the task of taking over from A N Prokof'ev the Directorate of Construction of the Palace of Soviets of the USSR Council of Ministers and of organizing the construction of Moscow State University in the Lenin Hills...*"

## 2. Personnel for the atomic industry in the earlier stages of the Atomic Project

The first acquaintance of the MSU staff with this specific atomic business took place in 1943. On April 3, Igor' Vasil'evich Kurchatov, the head of USSR Academy of Sciences Laboratory No. 2, wrote a memorandum to M G Pervukhin, Vice Chairman of the USSR Council of People's Commissars (CPC) and People's Commissar of the Chemical Industry, in which he pointed out that "*Prof. V I Spitsyn, Vice-Rector of MSU, and his collaborator V V Fomin, Candidate of Sciences in Chemistry, have been recruited by me into research on the chemical aspects of the uranium problem*" [3]. On 12 May 1943, two reports titled "Materials referring to the carbon chemistry" (written by Spitsyn) and "Materials referring to the uranium chemistry" (written by Spitsyn and Fomin) were passed on to Kurchatov [4]. While relations between Kurchatov, the scientific leader of the Soviet Atomic Project, and the faculty of the Chemical Department of MSU were businesslike, the same could not be said of the relations with physicists. The list of the research workers at Laboratory No. 2 as of January 18, 1944 shows that among the 22 scientists there were no specialists that had graduated from MSU. Only later graduates of the Physics Department of MSU appeared on the staff roster of Laboratory No. 2: V S Fursov (graduated in 1931) from May 22, 1944, and I N Golovin (graduated in 1936) from October 1944 (from August 21, 1950 to February 8, 1958 he was Kurchatov's first deputy).

Igor' Vasil'evich Kurchatov could have invited any competent physicist from MSU, but this did not happen. Why? The answer is that in the pre-war period only a few scientific institutions and scientists dealt with nuclear physics. It is a known fact that A F Ioffe, Director of the Leningrad Physical-Technical Institute (LPTI), was reprimanded for organizing studies in nuclear physics considered to have no practical potential. Thus, the trite reason lay in the fact that at the time there were very few nuclear physicists, so naturally Kurchatov invited to Laboratory No. 2 during its organization in late 1943 primarily those physicists whom he knew from his previous work at LPTI. Another reason was that the leading higher educational institutions in our country did not train specialists in nuclear physics. As for the Physics Department of MSU, which was one of the leading universities in the Soviet Union, the fact that specialists in nuclear physics were not trained followed from the state of affairs at the Department that existed at the time when work on the Atomic Project began. There are a number of publications (e.g., see Refs [5–10]) that study the state of affairs at the MSU Physics Department, and among these the work of A V Andreev (research worker at the S I Vavilov Institute of History of Natural Sciences and Technology of the Russian Academy of Sciences) [8] is worthy of note, who analyzed in detail the events that took place at the MSU Physics Department between 1922 and 1954. Hence, there is no need to repeat the content of the published materials, and I present the interested reader only with separate fragments and little-known facts that pertain to the state of training of scientists at the MSU Physics Department for the Atomic Project. It must be noted that the administrative and scientific leaders of the Atomic Project were fully aware of the importance of training highly professional personnel for the atomic industry; this problem was repeatedly discussed at all levels, and much was done (this might be a topic for a separate paper). Nevertheless, solving this problem, as pertaining to the MSU Physics Department, took many years. Below I discuss this problem in greater detail.

## 3. The anxiety of the academicians

A negative characteristic of the state of affairs at the MSU Physics Department was given by Academician V A Fock who, after heading the Chair of Theoretical Physics of the department for two months, on July 5, 1944 wrote a detailed letter to Academician P L Kapitza, which was published in Ref. [8]. Here, I only note that on the basis of his analysis Fock suggested the following: "(*a*) *to solicit the Government to appoint an authoritative commission consisting of physics academicians that would study the state of affairs at the department, and* (*b*) *to press for a change in the governing body of the department, i.e., fire the dean, Prof. A S Predvoditelev*".

The above letter made it possible for Kapitza to initiate the writing and sending of a letter to V M Molotov, Vice Chairman of CPC, signed by Academicians Ioffe (Academician-Secretary of the Division of Physical and Mathematical Sciences, or DPMS, of the USSR Academy of Sciences and Vice President of the Academy), A N Krylov, Kapitza, A I Alikhanov, L I Mandel'shtam, and N D Papaleksi. The

letter was forwarded on July 11, 1944, and some excerpts from it are given below [10]:

"*Over the course of many years the state of affairs in training young specialists at the Physics Department of Moscow State University is a cause for our serious concern.*

*The situation at the department is aggravated by the fact that instead of the modern branches of science the most backward trends, which often transform into pseudoscience, are developed.* [...]

*Moscow University should be one of the leading universities in our country. With the given state of affairs at the Physics Department, it is clearly unable to train physicists of the highest caliber.*"

As noted in Ref. [11], this document was augmented by a draft of a letter[1] from Kurchatov to Molotov, in which Kurchatov agrees with this opinion of the academicians and proposes assigning Kapitza to the position of Dean of the Department.

On October 19, 1944, Ioffe once more returns to the problem of training physicists and sends a memorandum to the Bureau of DPMS titled "Urgent measures needed for strengthening the pool of research workers in physics" [12]. In his memorandum, Ioffe stresses the need to assign to work at the universities "*prominent scientists capable of forming their own scientific schools. This has been done, for instance, in* (1) *Moscow*: *Kapitza, Kurchatov, Tamm, Skobel'tsyn, Landau, Vlasov, and Arkad'ev...*".

Although, as is known, some leading scientists were later forced to leave the MSU Physics Department.

A fairly detailed characteristic of the unsatisfactory state of affairs at the Physics Department was given by I S Galkin (former Rector of MSU) in his memoirs, where he stressed that to a certain extent this position has been supported by the Dean of the Physics Department, A S Predvoditelev, who "*...saw in the new branches of science the potential cause of destruction of national science and elements of worship of Western values*" [9]. Next, Galkin points out that the talks he had with the MSU Vice-Rector I M Vinogradov (a mathematician) and the physicists S I Vavilov, Kurchatov, and Skobel'tsyn convinced him that "*the egregious lagging of the MSU Physics Department far behind the level of modern requirements can no longer be tolerated. Time was a crucial factor, and yet decisions concerning the training of personnel that would be able to work in modern physics were constantly postponed on the pretext that the new areas of physics allegedly contradicted the national school of physics. This seemingly patriotic but actually antiscientific motive was, unfortunately, supported by V Nozdrev, assistant professor of the Physics Department and secretary of the MSU Party Committee, thus disorienting and confusing the scientists of the department.*"

Hence, there are many evidences of the contemporaries who understood the deplorable situation at the MSU Physics Department and spared no pains to improve it.

At the same time, as a memorandum prepared by the Ministry of Higher Educational Institutions and entitled "On the professors and doctors of sciences working in the field of physics and entering the body of teachers at state universities in 1944/1945" [13] indicates, the faculty of the MSU Physics Department included many well-known scientists. Among these were

— D I Blokhintsev, Professor of the Chair of Theoretical Physics;

— N N Bogolyubov, Professor of the Chair of Theoretical Physics;

— I M Frank, Professor of the Chair of Atomic Nucleus;

— D D Ivanenko, Professor of the Chair of Theoretical Physics;

— S G Kalashnikov, Professor of the Chair of General Physics;

— P L Kapitza, Head of the Chair of Low Temperatures;

— S E Khaikin, Head of the Chair of General Physics;

— S T Konobeevskii, Head of the Chair of X-ray Structural Analysis;

— L D Landau, Acting Professor of the Chair of Low Temperatures;

— M A Leontovich, Head of the Chair of Optics;

— E M Lifshitz, Associate Professor of the Chair of Low Temperatures;

— A I Shal'nikov, Acting Professor of the Chair of Low Temperatures;

— D V Skobel'tsyn, Head of the Chair of Atomic Nucleus;

— P G Strelkov, Professor of the Chair of Low Temperatures.

The whole list included 46 scientists.

The Physics Department also employed such prominent scientists as G S Landsberg, Mandel'shtam and Tamm, to mention just a few. Here we will not discuss the struggle between these scientists and a group of reactionaries at the Physics Department (for more details see Refs [5–9]). In Ref. [13] there is also a list of textbooks prepared and published by the professors of the MSU Physics Department: *Quantum Mechanics* (Blokhintsev), *A Course of Theoretical Physics* in 3 volumes (Landau, Lifshitz, and Khaikin), *Statistical Physics* (Leontovich, D I Sakharov, and Kalashnikov), and *College Physics* (Landau). A book by Kurchatov, *Physics of the Atomic Nucleus*, is also mentioned among those planned for publication (however, it was never published).

## 4. First organizational decisions

The efforts of the scientific community were not in vain. On February 21, 1945, Resolution No. 7572ts/pi "On the training of specialists in nuclear physics" was adopted by the State Defense Committee (SDC) [14]. The resolution stated the following:

"*In order to make up the staff of USSR Academy of Sciences Laboratory No. 2 and research institutes working together with it on special assignments from the SDC in the field of nuclear physics with highly qualified personnel, the State Defence Committee orders*:

1. *To bind the Committee of Higher School Affairs of the USSR CPC* (*Cde. Kaftanov*) *and the RSFSR People's Commissariat of Education* (*Cde. Potemkin*) *to ensure graduation from Moscow State University of the following number of physicists specializing in nuclear physics: 10 graduates in December 1945, 25 graduates in 1946, and no fewer than 30 graduates each year beyond 1946.*"

Item 7 of the resolution reads:

"*To bind the Rector of Moscow State University* (*Cde. Galkin*) *to organize in three months a laboratory of*

[1] In Ref. [8], the document was called "The letter of four academicians" with a reference to Kapitza's archive. Actually, as Ref. [11] clarifies, this letter was also signed by Academicians L I Mandel'shtam and N D Papaleksi.

*nuclear physics, allocate an additional area of 200 square meters, and supply the necessary machinery and equipment at the expense of other laboratories of the university*.''

The resolution also listed the special assignments given to various People's Commissariats (ministries) and the Moscow City Executive Committee, including Red Army draft exemption for students, teachers, research workers, engineers, assistants, and other personnel of the Chair of Nuclear Physics of MSU, elevating stipends for the students of the Chair of Nuclear Physics, and a number of other organizational measures. It also assigned to Laboratory No. 2 a number of physics students of MSU as well as radiochemists and other specialists from higher educational institutions in the USSR. The Committee of Higher School Affairs and MSU were charged with the task of developing by May 15, 1945 suggestions concerning the building of a cyclotron with an electromagnet weighing 20 to 25 tons at MSU in 1945.

Strictly speaking, the answer to the question of why there were no graduates of the MSU Physics Department on the staff of Laboratory No. 2 is also contained in the above resolution — the department simply did not train specialists in nuclear physics prior to the Atomic Project for both the ideological reasons (the political standing of the leadership of the department) and because there was no experimental base for training students in the field of nuclear physics.

The administrative and scientific leadership of the Atomic Project understood that in order to train the necessary personnel focussed on solving the enormous problems associated with creating nuclear weapons, the number of students, future specialists for atomic science and industry, had to be increased. Hence, a year later, on January 28, 1946, USSR CPC Resolution No. 226-96ts ''On the training of physics engineers and specialists in nuclear physics and radiochemistry'' was released [15]. The resolution comprised 20 items, and most of these concerned MSU and dealt with the establishment of an experimental base for training specialists and conducting research. MSU was charged with the task of turning out (in 1946 and 1947) 70 and 80 physicists specializing in nuclear physics, and 9 and 15 radiochemists (respectively). In particular, the RSFSR People's Commissariat of Education and the MSU Rector Galkin were charged with the task of organizing in the first quarter of 1946 at MSU the Institute of Nuclear Physics and incorporating the radiochemical laboratory into it. A Corresponding Member of the USSR Academy of Sciences, Skobel'tsyn, was designated as the Director of the new institute. The main assignment for the Institute of Nuclear Physics was to arrange practical work for the students of senior courses of the MSU Physics and Chemistry Departments in the field of nuclear physics and radiochemistry and to pursue actual investigations in this field.

The understanding of the unsatisfactory situation with the training of qualified personnel for modern physics research made it possible for Galkin, the MSU Rector at the time, together with the Vice-Rector I M Vinogradov, Academicians Vavilov and Kapitza, and the Corresponding Member of the USSR Academy of Sciences Skobel'tsyn, in consultation with A V Kaftanov, Minister of Higher and Secondary Special Education, to initiate the issuing of a governmental resolution on the organization of a Physics and Technology Department at MSU. Such a resolution was approved by I V Stalin on November 25, 1946 [16]. This resolution stipulated the training of specialists in nuclear physics, the physics of combustion and explosion, radio physics, optics, supersonic aviation, and jet engine. The building of the former Institute of Zeppelin Construction in the Dolgoprudnaya railroad station on the outskirts of Moscow were used to accommodate the new department, and Academician S A Khristianovich was appointed dean of the department. The first and only group of graduates with MSU diplomas was in 1952, although in 1951 the department was transformed into the Moscow Institute of Physics and Technology (former Moscow Physical-Technical Institute) (MIPT). Some students majoring in the structure of materials were transferred to the MSU Physics Department, and others to the Moscow Institute of Engineering Physics (MIEP), since the specialization was terminated at the Moscow Institute of Physics and Technology. The answer to why this happened merits a special historical study. Among the graduates of the Chair of the Structure of Materials, worth noting were such well-known physicists as Academician S T Belyaev and Hero of Socialist Labor Professor G A Goncharov. There was a request by Academician A I Alikhanov, Director of the Thermo-Technical Laboratory (TTL), to assign several graduates of the MSU Physics and Technology Department specializing in the structure of matter to work at the laboratory. The list included Goncharov, P A Krupchitskii, I A Radkevich, V V Sudakov and others — nine graduates in all [17]. These young researchers were directed to work at the TTL, except for Goncharov who was forwarded to Design Bureau No. 11 (KB-11 in Arzamas-16).

However, the plan of turning out specialists for work in the Atomic Project was fulfilled by the USSR Ministry of Higher Education only by 44.8%. In view of this, the FMD leaders M G Pervukhin, N A Borisov, and P Ya Meshik sent around a memorandum on this issue to Beria [18], in which they stated that in 1946 – 1947 only 157 young specialists in nuclear physics, radiochemists, and physics engineers graduated, instead of the 350 graduates according to the plan stipulated by the resolution [15]. They suggested setting the target of turning out specialists for the FMD at 1000 graduates in 1949, and 1350 graduates in 1950. The authors of the memorandum also noted that some graduates did not receive security clearance for work at the FMD facilities, although they were cleared by the 'K' Department of the USSR Ministry of State Security for admission to the departments of the universities. As a result, on December 17, 1948, a new USSR Council of Ministers resolution was issued [19]: ''On the training by higher educational institutions of specialists for the First Main Directorate of the USSR Council of Ministers''. The resolution set the targets for turning out specialists in atomic science and technology at 17 institutions of higher learning in the USSR, including MSU. Item 2 of the resolution stated:

''*To concentrate the training of specialists for the First Main Directorate of the USSR Council of Ministers at the following educational institutions*:

— *M V Lomonosov Moscow State University* (*Rector Cde. Nesmeyanov*);

— *Second Research Institute of Physics affiliated to M V Lomonosov Moscow State University* (*Director Cde. Skobel'tsyn*).''

The list also included 15 other universities and institutes.

In particular, the MSU Physics and Technology, Physics, and Chemistry Departments and the MSU Second Research Institute of Physics had to turn out 160, 195, and 210 specialists for work at the FMD facilities in 1949, 1950, and 1951, respectively, which were much higher figures than those

for 1945 – 1946. The data listed below on the plans of turning out physicists from MSU (broken down by year) according to the governmental resolution indicate that the demand in qualified personnel for the FMD had not be fulfilled:

| Years | 1949 | 1950 | 1951 |
|---|---|---|---|
| Physics and Technology Department: | | | |
| experimental nuclear physics | — | — | 10 |
| physics of isotopes | 10 | 15 | 10 |
| electrophysics | — | — | 10 |
| physics and mechanics of explosions | 10 | 10 | 15 |
| Physics Department: | | | |
| spectroscopy division | 10 | 15 | 15 |
| Second Research Institute of Physics: | | | |
| theoretical nuclear physics | 10 | 15 | 15 |
| experimental nuclear physics | 30 | 30 | 30 |
| electrophysics | 20 | 20 | 20 |
| radiological protection | 20 | 25 | 25 |

The steps that were taken made it possible in the course of 1948 – 1951 to send to the FMD facilities a great number of graduates who majored in the structure of matter at the MSU Physics and Technology Department and Physics Department, but still the targets stipulated by the above resolutions were not met. The actual data on the distribution of graduates of the MSU Physics and Technology Department and Physics Department among the FMD facilities for research in atomic science in the period from 1948 to 1951 are gathered in Table 1 [20].

Table 1 shows that in the period from 1948 to 1951 only 96 young research workers, i.e., approximately 25 people each year, were directed to work at the FMD facilities, which is a much smaller number than that indicated in the graduation plans according to the resolution [19]. Of course, 10 physicists assigned to jobs in the FMD system is clearly an insufficient number for work on the Atomic Project. At the same time, the physicists that graduated from the MSU Physics Department in the period from 1948 to 1951 can be considered lucky because many of them, together with older physicists from MSU and other universities, took part in work on improving nuclear weapons, developed the first hydrogen bomb RDS-6s and the thermonuclear charges that followed, built the first nuclear power plant in the world and the first Soviet atomic submarine, and did research in thermonuclear fusion.

In 1949 – 1951, the following graduates of the MSU Physics Department were assigned to jobs at KB-11 [20]:

graduates of 1949: V B Adamskii, V N Klimov, E V Polunskaya, and D V Shirkov;

graduates of 1950: Yu N Babaev, E K Bonyushkin, L P Feoktistov, B P Khrustalev, I N Paramonova, V I Ritus, V I Sbitnev, M P Shumaev, A M Voinov, G B Voinova, and N V Zakharova;

graduates of 1951: Yu V Anishchenko, B D Bondarenko, V M Chistov, M I Kazarinova, Yu S Klintsov, A A Malinkin, E I Sirotin, and Yu V Strel'nikov.

At the beginning of 1949, the Chair of the Structure of Matter at the Physics Department was used as the base for creating the Division of the Structure of Matter. It comprised five chairs and was headed by Academician Skobel'tsyn. Third-year students (a total of 113 people) were selected to study at this division. Among these were A K Bakhtadze, V S Barashenkov, E V Chvankin, V S Imshennik, B B Kadomtsev, V G Neudachin, Yu V Nikol'skii, V D Sharanov, V S Stavinskii, S I Syrovatskii, I B Teplov, I M Ternov, A F Tulinov and others.

On June 11, 1962, the MSU Rector I G Petrovskii forwarded a letter to Beria in which he described the situation on training physicists at the MSU Physics Department, excerpts from which are given below [21]:

"*The Soviet government has built for the Physics Department of Moscow State University a beautiful building in the Lenin Hills and supplied the department with beautiful, invaluable equipment. All this should be used most effectively in developing research and in training highly professional physicists. With the present state of affairs, our Physics Department cannot solve these problems because the teaching staff in a number of chairs is poorly qualified, while many outstanding physicists, even those doing research in Moscow, are not recruited for work at the university. Hence the need for a drastic reorganization of the Physics Department of our university. To do this, the department must be headed by a person who understands the main problems posed by physics, has authority with scientists, has organizational capabilities, and could fully devote his time to the work in our Physics Department. It is highly important that this person knew the needs of FMD, for which we train many specialists. The present Dean of the Physics Department does not meet these requirements.*"

Further in his letter, Petrovskii suggests offering the post of dean to I I Novikov, the Head of the R&D Department of

**Table 1.** Number of graduates of the MSU Physics Department sent to work at FMD facilities in the period from 1948 to 1951.

| Name of FMD facility | | Years | | | |
|---|---|---|---|---|---|
| Old | Modern | 1948 | 1949 | 1950 | 1951 |
| Laboratory No. 2 | Russian Research Centre 'Kurchatov Institute' | 2 | 4 | 4 | 12 |
| KB-11 | RFYaTs — VNIIEF | | 4 | 11 | 8 |
| Laboratory No. 3 | Russian Federation State Scientific Center 'A I Alikhanov Institute for Theoretical and Experimental Physics' | | 1 | 2 | 1 |
| Laboratory 'V' | Russian Federation State Scientific Center 'A I Leipunskii Physico-Energy Institute' | 1 | 3 | | 6 |
| Institute 'A' | | | | 2 | |
| Institute 'B' | | 1 | 2 | 1 | |
| Plant No. 817 | Production Association 'Mayak' | 5 | 3 | 4 | 2 |
| Plant No. 813 | Ural Electrochemical Plant | | 2 | 3 | |
| Factory No. 12 | Elektrostal' Mechanical Factory, Inc. | | | 6 | |
| GSPI-12 | State Specialized Design Institute | | | 1 | 1 |
| FMD | Federal Atomic Energy Agency (Rosatom) | 1 | | 3 | |
| | Total | 10 | 19 | 37 | 30 |

the FMD; if this is impossible, then the FMD should propose its own candidate.

In conclusion, Petrovskii expresses his appeal:

"*I would like to ask you to charge FMD with helping us in acquiring a number of scientists working in the FMD system to teach and do research at our Physics Department.*

*First, I would ask you to appoint to the Head of the Chair of Theoretical Physics an outstanding theoretician, N N Bogolyubov, laureate of the Stalin Prize and Corresponding Member of the USSR Academy of Sciences, because the present Head of the Chair is absolutely unfit for this post. I believe the task of training theoretical physicists is of top priority.*"

This letter was considered by Beria, who charged FMD heads A P Zavenyagin and V S Emel'yanov and the scientific leader of the Atomic Project Kurchatov (although there was no such official position in the Atomic Project, Kurchatov was actually the supervisor of the project) with preparing appropriate recommendations. Their recommendations were sent to Beria on October 4, 1952 [22], and they suggested appointing V P Peshkov (a graduate of the MSU Physics Department of 1940, who in 1947 – 1949 was Deputy Director of the S I Vavilov Institute for Physical Problems) Dean of the MSU Physics Department, and Bogolyubov, Head of the Chair of Theoretical Physics. However, as further events showed, neither Peshkov nor Bogolyubov was appointed. Moreover, for a year after Petrovskii's letter, nothing was done to normalize the situation at the Physics Department.

A remark is in order. The documents cited imply that the situation at the MSU Physics Department was quite obvious to the leading physicists inside the country, who initiated a number of governmental resolutions, which made it possible to implement important organizational measures and to increase the number of nuclear physicists trained not only at MSU but also at other universities and institutes. Despite these resolutions, Petrovskii's letter leaves a strange feeling, as though the Rector was unable to do anything to improve the moral climate at the department, so strong was the opposition to this. The explanation lies, primarily, in the position of the Party organization at MSU, mentioned by Galkin in his memoirs (see above), and in the letter by K P Ponomarenko (Minister of Culture), V A Malyshev (Minister of the Middle Engineering Industry), A N Nesmeyanov (President of the USSR Academy of Sciences), and M V Keldysh (Academician-Secretary of the Division of Physical and Mathematical Sciences of the USSR Academy of Sciences) to the Presidium of the CPSU (Communist Party of the Soviet Union) Central Committee, dated November 12, 1953 (quoted according to Refs [7, 8]). In this letter, among other things, it was pointed out that

"*The MSU Physics Department trains students in basic physical professions on a much lower level than required by the needs of the modern development of physics and the respective areas of industry.* [...]

*For many years, the MSU Physics Department has been ruled by a group of unprincipled scientific workers that, to a great extent, lack the necessary scientific and pedagogical qualifications.*

*At the proper time, the members of this group forced a number of outstanding physicists, among them Academicians V A Fock, M A Leontovich, and I E Tamm and Corresponding Member S T Konobeevskii, to leave Moscow University.*"

As for the position of Petrovskii, the authors of the letter write the following:

"*All attempts by MSU Rector I G Petrovskii to enlist the services of outstanding scientists as faculty members were not taken kindly to by this reactionary group, and Academician I G Petrovskii was even accused of advocating a cult of personality and trying to use the authority of prominent scientists to crush all initiative of young scientists by pushing them into the background.*"

Actually, the situation improved only a year after the above-mentioned Petrovskii appeal, but more about this below.

The intrigue resided in the fact that students in the senior courses of the Physics Department, possibly knowing nothing of Petrovskii's letter, came to understand that something must be done with the educational process at the department. In the fall of 1953, the 4th Annual Conference of the Young Communist League (YCL) at the department passed a resolution stating that a letter must be written and forwarded to the CPSU Central Committee, concerning the unsatisfactory training of students. Without going into details dealing with this YCL action, about which the interested reader can find more information in Ref. [7], I would like to say that at that time I was a fourth-year student in the Division of the Structure of Matter and was a direct witness to all the events. My classmate V P Karasik, who later worked at the Physics Institute of the Russian Academy of Sciences (RAS), actively participated in organizing and holding the conference, while V B Rozanov, today's Chief Researcher of the RAS Physics Institute, laureate of the Lenin Prize, worked in the commission that wrote the letter to the CPSU Central Committee.

The result of the letter of the MSU Physics Department students, written despite strong opposition from the MSU Party Committee, and the letter of Ponomarenko, Malyshev, Nesmeyanov, and Keldysh to the CPSU Central Committee, was a decision of the Presidium of the CPSU Central Committee, taken on December 7, 1953, on forming a commission headed by V A Malyshev (Minister of the Middle Engineering Industry) and having as its members S Kaftanov, I Kurchatov, A Nesmeyanov, I Petrovskii, A Rumyantsev, and G Alekseenko. On February 2, 1954, the commission forwarded its recommendations to the CPSU Central Committee together with a draft of a resolution (the full text of the commission's conclusion has been published in Ref. [8]). Here are some excerpts of this conclusion that touch on measures for improving the teaching process at the MSU Physics Department:

"(*a*) *to strengthen the leadership of the MSU Physics Department*;

(*b*) *to revise the curricula and programs of the department with the aim of making lecture courses ...* [...];

(*c*) *to enlist the services of outstanding specialists in new areas of physics as additional faculty members...*".

The results of the work of Malyshev's commission were used in a resolution adopted by the CPSU Central Committee on August 5, 1954 and titled "On measures for improving the training of physicists at MSU", which stipulated drastic measures aimed at improving the moral climate at the Physics Department according to the commission's conclusion (for more details see Ref. [8]). Item 3 of the resolution stated the following:

"*To designate Cde. V S Fursov as Dean of the MSU Physics Department and to relieve Cde. A A Sokolov of his post of dean. To allow Cde. V S Fursov to continue his work at the Ministry of Middle Engineering Industry.*"

From the personal file of Fursov [23]:

"*1931, graduation from MSU, with a certificate* (*instead of a diploma*) *issued on August 14, 1931, in which it was stated that "citizen Vasilii Stepanovich Fursov is presented with this certificate as proof of graduation from the Physics Division of the MSU Physics and Mathematics Department, where he majored in theoretical physics"*;

*1931 – 1939, postgraduate student, Assistant, and Associate Professor at the MSU Physics Department*;

*1937, defence of a Candidate thesis "Density fluctuations in Fermi gas"*;

*1939 – 1941, acting head of the Chair of Theoretical Physics at MSU*;

*1941 – 1944, service in Red Army*;

*1944 – August 1954, work in Laboratory No. 2*;

*from 1947, head of Sector No. K-15 of the Department of Optical Devices* (*this is the name under which the Department of Nuclear Reactors was known*) *of Laboratory No. 2*;

*from December 22, 1948 to March 15, 1951, scientific leader of the first industrial uranium – graphite reactor at Plant No. 817*;

*from July 7, 1951 to August 1954, deputy scientific leader* (*of I V Kurchatov*) *of Plant No. 817, responsible for reactors.*

*Has been awarded the Order of Lenin among other participators that have received government awards for the successful test of the first Soviet atomic bomb, thrice laureate of the Stalin Prize* (*1949, 1951, and 1953*)."

The character reference signed by Kurchatov on January 27, 1946 says that

"*Cde. V S Fursov has been highly successful in his work in theoretical physics. He is a thoughtful research worker and always does a profound analysis of the problems he studies.*"

Of course, for security reasons, Kurchatov could not give a more detailed character reference in an unclassified document.

Fursov's personal file contains a detailed character reference of him as a Senior Researcher filling this position from May 22, 1944, signed by A B Migdal, the Head of Sector No. 10 of Laboratory No. 2:

"*During his work in Laboratory No. 2, V S Fursov gained merited authority as a knowledgeable theoretical physicist by his thorough research and careful analysis of the many actual theoretical problems he solved working for the Laboratory.*

*Researchers at the Laboratory benefited greatly from his exceptionally clear lectures in nuclear theory, which contributed greatly to raising their level of theoretical competence.*"

According to the staff report signed by the new dean on December 14, 1954, among the physicists that were invited to read lectures at the Physics Department were Academicians L A Artsimovich, I K Kikoin, L D Landau, M A Leontovich, I E Tamm and Professor S Yu Luk'yanov.

All these measures contributed to normalizing the situation at the Physics Department and substantial improving the training of future physicists.

## 5. Moscow State University physics alumni in the Atomic Project

Many MSU graduates actively participated in the Soviet Atomic Project and in the formation of national atomic science and industry, irrespective of what positions they held. Some became well-known scientists, laureates of Nobel, Lenin, Stalin, State, and Lomonosov Prizes, Heroes of Socialist Labor, directors of institutes and unique facilities, etc. Others were simply irreplaceable research workers gathering invaluable crumbs of knowledge. Among the MSU alumni that participated in the Atomic Project were outstanding scientists. Note that another important factor contributing to the success of the Atomic Project was that a very good fundamental education was given to pre-war students at the MSU Physics Department, which made it possible for many researchers who graduated from MSU before the war to contribute significantly to the solution of scientific and technical problems that confronted Kurchatov, the scientific leader of the Atomic Project, and the FMD, of which more will be said below. Some of them specialized in theoretical physics, others became experimenters. However, such specialization of physicists that graduated from MSU did not prevent theoreticians from occupying themselves with applied problems or experimenters from doing complicated theoretical calculations. For instance, D I Blokhintsev, who graduated from the MSU Physics Department in 1930, was known for his work in theoretical physics; when he participated in the Atomic Project, he was Director of Laboratory 'V' and was leader of scientists who built the first nuclear power plant in the world. At the same time, he headed a small group of theoreticians at Laboratory 'V' that theoretically justified a variant of the hydrogen bomb known as the 'tube' variant. V S Fursov, one of the close associates of Kurchatov and specialist in theoretical optics and quantum statistics, in a very short time mastered the physical methods of calculations of uranium – graphite reactors. V V Vladimirskii, who graduated from the MSU Physics Department in 1936 and was for many years Deputy Director of the Thermo-Technical Laboratory (headed by A I Alikhanov), equally well knew the theory and practice of heavy-water nuclear reactors, participated in the building of circular accelerators of charged particles (synchrotrons) with energies in the 10 – 70-GeV range, and was one of the inventors of the quadrupole focusing principle. Such examples abound. This phenomenon can be explained by the fact that in the pre-war years, despite the situation at the MSU Physics Department mentioned earlier, many outstanding Soviet physicists taught at the department, and these physicists implanted, in the students minds, the fundamental approaches needed for solving the emerging physical problems.

Another feature of the participation of MSU alumni in the Atomic Project was that two generations took part in the project: the older generation, those who graduated before the war, and the younger generation, those who graduated after the war, with the latter being fully ready to solve the scientific and technical problems associated with the Atomic Project and rapidly learning from older, more experienced, physicists. This symbiosis of physicists of the older and younger generations produced remarkable results in creating nuclear and thermonuclear weapons and in developing atomic science and technology, whose results we are still using today. It is characteristic that the post-war physicists, among whom there were many talented people, gradually acquired the knowledge and experience which made it possible for them in time to occupy the leading positions in Soviet atomic science and industry.

If we keep to the chronological sequence of events, we must first and foremost mention Academician Sergei Ivanovich Vavilov, who graduated from MSU in 1914 and did a lot for the development of atomic science in the research institutes of the USSR Academy of Sciences, being the Director of the Physics Institute of the Academy from 1932

to 1951, and President of the Academy from 1945 to 1951. In his memorandums for the Soviet Government of April 22, 1946 (''On the organization of research in various fields of science in connection with the problem of using the energy of the atomic nucleus'') and of September 13, 1946 (suggestion concerning the organization of research and a list of topics), Vavilov proposed an extended program of participation of research institutes of the USSR Academy of Sciences in the Atomic Project. These memorandums and the reports of the discussions that took place at the Scientific and Technical Council of the FMD and the Special Committee can be found in Ref. [24]. In his memorandum of September 13, 1946, Vavilov for the first time formulated the idea of ''*using uranium piles to generate electric power*'' (item 14 in the list of topics). In accordance with USSR Council of Ministers Resolution No. 2697-1113 of December 16, 1946, Vavilov was designated as a chairman of an academic council whose main purpose was to guide the R&D work in nuclear studies and in the use of atomic energy in technology, chemistry, biology, and medicine, done at the research institutes of the USSR Academy of Sciences and ministries. It must be noted, however, that Vavilov was not included in the Scientific and Technical Council of the FMD, maybe because of his heavy workload as President of the Academy of Sciences.

Among the oldest MSU graduates was I E Tamm who, after his stay at Edinburgh University in 1913 – 1914, studied at MSU and graduated from the Physics and Mathematics Department in 1918. In 1948, Kurchatov invited him to head a small group of theoretical physicists (Tamm was then Head of the Theoretical Division of the Physics Institute of the Academy of Sciences) with the task of substantiating computationally the idea of a hydrogen bomb. This group was organized on the basis of USSR Council of Ministers Resolution No. 1990-774 of June 10, 1948. The respective item was included in the resolution on the suggestion of B L Vannikov and Kurchatov. The official task of the group was to develop a theory of nuclear combustion of deuterium, but actually the group was supposed to investigate by theoretical means the possibility of creating a hydrogen bomb. The group included four graduates of the MSU Physics Department — S Z Belen'kii (graduated in 1938), Ginzburg (1938), Sakharov (1942), a postgraduate student Yu A Romanov (1947) — and E S Fradkin. Later, Tamm (Hero of Socialist Labor) and Ginzburg became Full Members of the USSR Academy of Sciences and Nobel Prize Winners in Physics, and Sakharov became a Full Member of the Academy, was awarded the Nobel Peace Prize, and was triply honored with the title of a Hero of Socialist Labor. Sakharov proposed a layered structure for the hydrogen bomb, which became known as 'sloika' (or Layer Cake). He also contributed remarkably to the development of a two-stage hydrogen bomb based on the principle of radiative implosion (RDS-37).

From the personal file of A D Sakharov [25]:

''*1938 – 1942, student at MSU*;

*1942 – 1945, engineer at the Ministry of Armaments Factory No. 3, Ul'yanovsk city*.''

Let us leave for the time being Sakharov's personal file and quote an extract from the memorandum ''Key problems of theoretical physics (elementary particles, ultrahigh-energy physics, the atomic nucleus)'' signed by Tamm, Ginzburg, I Ya Pomeranchuk, E L Feinberg, and M A Markov, which was forwarded to the FMD and reflected on this period in Sakharov's life [26]:

''*Rather many talented theoretical physicists that have received special training were squandered, and after graduating work as engineers at factories and teach at schools, i.e., are not used to their full capacity*.''

Clearly, the example of Sakharov and other facts allowed the authors of the memo to come to such a conclusion. Back to the file:

''*1945 – 1947, postgraduate student at the Physics Institute of the USSR Academy of Sciences*;

*November 3, 1947, successful defence at the academic council of the Physics Institute of his thesis* ''*The theory of nuclear transitions of the* $O \rightarrow O$ *type*'' *for Candidate of Physicomathematical Sciences*;

*1947 – 1950, research worker at the Physics Institute of the USSR Academy of Sciences*;

*1950 – 1954, head of a laboratory at KB-11*;

*1954 – 1956, head of sector at KB-11*;

*1956 – 1966, deputy scientific leader, head of sector at KB-11*;

*from 1966 to the present time* (*1968*), *deputy scientific leader of VNIIEF responsible for general physical problems*.''

Sakharov's personal file contains a reference to an announcement in the *Izvestiya* newspaper of January 28, 1980, which states the following:

''*Taking into consideration the numerous suggestions of the public, the Presidium of the USSR Supreme Soviet has decided to strip A D Sakharov of his title of a Hero of Socialist Labor and all government awards, and the USSR Council of Ministers, the titles of laureate of all the prizes awarded to him*.''

It is impossible to forget this shameful persecution of an outstanding citizen and scientist of our country. I believe that if Kurchatov had been alive at the time, he would never have allowed such a thing to happen.

The character reference of Sakharov, signed by Kurchatov, Yu B Khariton, and Ya B Zel'dovich on September 13, 1953 in connection with Sakharov's election to the USSR Academy of Sciences, gives an idea of how much Sakharov contributed to the development of the 'sloika' type hydrogen bomb [27]. Since this document has never been published before, I give it here in full.

''*To Cde. V A Malyshev*.

*A D Sakharov was recruited to work at KB-11 in 1948. At that time, the Physics Institute of the Academy of Sciences* (*I E Tamm*) *was given the task to do calculations needed for the design of a deuterium bomb* (*RDS-6t*). *After some time, Sakharov proposed an essentially different scheme of hydrogen bomb, a gadget with a multilayer charge. After his idea had been discussed and several modifications were made in the proposal* (*such as compression and introduction of tritium*), *it was decided to implement the idea as soon as possible.*

*It must be noted that the gadget with a multilayer charge appeared realistic thanks to two important physical effects predicted by Sakharov. As a result of strong ionization of the gadget with a multilayer charge subjected to atomic heating, the ratio between the numbers of free particles in the heavy and light layers changes, and additional compression of light layers from the side of heavy layers occurs, thus increasing the rate of the fusion reaction. The second effect is associated with the fission of uranium nuclei by neutrons generated in the course of fusion reaction. As a result, the overall explosive power increases considerably.*

*In solving a group of extremely complicated problems associated with building a gadget based on this idea, Sakharov*

*showed his worth as an outstanding scientist. Large groups of mostly qualified Soviet physicists and mathematicians worked in close contact with him on his task orders.*

*The results of tests of the RDS-6s gadget confirmed the predictive powers of Sakharov.*''

Let us now take a break in the extensive quotation and turn to Ginzburg's proposition. It is a well-known fact that physical intuition plays a great role in research. One such an example is the idea of Ginzburg, which he proposed at the beginning of work on the hydrogen bomb in 1948. The idea was to utilize lithium-6 in the form of lithium deuteride in the thermonuclear charge.

Back to Sakharov's character reference letter:

''*During work on the RDS-6s gadget, Sakharov made two additional fundamental conjectures.*

*In 1950, he formulated the principle of a magnetic thermonuclear reactor* (*MTR*), *which a group of physicists headed by Artsimovich, Leontovich, and Golovin are now actively developing at the Laboratory of Measuring Instruments.*

*In 1951, Sakharov suggested the idea of strong compression via the transformation of the energy of an explosion into electric energy, generation of short magnetic-field pulses with a strength of tens of millions oersteds* (*the record was 300,000 Oe generated by Kapitza*), *and the use of such pulses for compression. Computations show that by implementing Sakharov's idea we could build gadgets* [*hydrogen bombs*] *that would be much smaller and, possibly, could use smaller amounts of active materials with good efficiency.*

*A D Sakharov is an exceptionally gifted theoretical physicist and at the same time a remarkable inventor. Such a combination of the initiative and purposefulness of an inventor with the depth of scientific analysis of a researcher resulted in a situation in which in a very short period of six years A D Sakharov has achieved remarkable results which has put him in a first place in the Soviet Union and the world over in the most important branch of physics.*

*Having begun his work in this area of physics in 1948, Sakharov put forward a suggestion that plotted entirely new paths of solving the most important problem. His suggestion was bold and profound, and its value has been acknowledged by specialists. The years that followed saw intensive work on the realization of his suggestion, work that culminated in the remarkable result reached in 1953.*

*I Kurchatov*
*Yu Khariton*
*Ya Zel'dovich.*''

Indeed, the combined effort of Tamm's group and the specialists at KB-11 produced brilliant results in creating the first hydrogen bomb.

The signatures of Tamm and Sakharov were put under the deed of readiness for the first hydrogen bomb and under the report on hydrogen bomb tests, together with the signatures of Kurchatov, Khariton, Zel'dovich, and other specialists of KB-11 and the FMD. The report on hydrogen bomb tests was also signed by D I Blokhintsev, a graduate of the MSU Physics Department in 1930. With the deed of readiness, the archive file also contains a priceless document entitled ''A model of the RDS-6s gadget'', prepared by Sakharov and signed by Tamm, Sakharov, and Zeldovich [28]. According to the accepted practice, several terms, such as neutrons, KB-11, RDS-6s, nuclear explosion and some others were written in by Sakharov's hand. The description of this model comprises the following sections:

''*1. Principle of operation and the basic characteristics of the RDS-6s gadget.*
*2. Research of the processes taking place during operation of the RDS-6s gadget*:
*A. Nuclear research*
*B. Research of compression processes*
*C. Mixing of layers in the explosion process*
*D. Calculations of processes taking place in a nuclear explosion and the power of the gadget.*
*3. Reliability analysis of the RDS-6s gadget.*
*4. Tasks and methods of the tests of the RDS-6s gadget.*''

This document carries one of the best descriptions of the physical peculiarities, principle of operation, and the layout of the hydrogen bomb. The time will probably come when this document will become available to the scientific community. It is no coincidence that Sakharov said that ''*the hydrogen bomb is a delight for theoreticians*''. When you look at the deed of readiness and the description of the ''Model'' and see the signatures of Russia's outstanding physicists, your heart skips a beat, and you feel proud of the country where they lived and did research.

As noted in Ref. [28],

''*A number of quantities needed for calculating the explosion process, such as heat conductivity and the equation of state of uranium at a temperature of hundred million degrees, the nature of mixing, viscosity, and diffusion, were calculated at the Physics Institute of the USSR Academy of Sciences. An essential part of the preparatory work done at KB-11 amounted to working out a method for calculating the diffusion and moderation of neutrons and to determining the constants needed for the calculations from nuclear experiments.*''

The successful test of the first Soviet thermonuclear bomb on August 12, 1953 at the Semipalatinsk test site was the result of the joint work of Tamm's group of theoretical physicists and the scientists' and designers' collective at KB-11 headed by Khariton, and also the groups headed by Landau and A N Tikhonov.

Professor Goncharov (the Chief Researcher at RFYaTs — VNIIEF, active participant in the program of developing the hydrogen bomb, including RDS-6 and RDS-37, and the later improved bombs, Hero of Socialist Labor, and laureate of Lenin and State prizes — *G V K*) recalls that

''*I studied in the MSU Physics and Technology Department in 1946–1952*; *my practical work prior to graduation and the defence of the university diploma was done at the Thermo-Technical Laboratory* (*TTL*) *in the department of Professor V S Migulin; my scientific adviser was O V Vladimirova. The topic of my graduate thesis was the development of an experimental nuclear magnetic resonance device with the aim of measuring the gyromagnetic ratios of various nuclei. I was able to build such a device, in which all the electronic circuitry I put together with my own hands. When the device was switched on, the entire staff of the laboratory gathered around it to see the resonance peaks on the screen of the oscilloscope. Even A I Alikhanov, Director of TTL, came to see it. I liked my work in the laboratory, so I told Alikhanov of my desire to stay on after graduation. He promised to apply to FMD apropos of my assignment, but said that it could be late* (*our conversation took part in October 1951*). *Fifty years later, in the archives of former FMD, I found Alikhanov's letter with his request for my assigning to TTL* [17], *i.e., Abram Isaakovich* [*Alikhanov*] *stuck to his word!*

*But fate had it differently, and in 1952 I was sent to KB-11, where I began work at the department headed by V Yu Gavrilov and had to do with critical assemblies. In the same year I was attached to Sakharov's department, where I participated in calculations of thermonuclear charges. In 1953, I was transferred to a permanent job at Sakharov's department. One of my tasks was to gather, analyze, and test on model assemblies the base of constants for calculations of hydrogen charges. The results published in the literature and the data from various research institutes and laboratories — KB-11, the Physics Institute of the USSR Academy of Sciences, the Hydraulic Engineering Laboratory* (*HEL*), *and Laboratories No. 1 and 'V' — were used as the initial data. At this stage, I developed an algorithm for calculating group constants, which made calculations of charge models more easy. At the same time, I was involved in preparing task orders for HEL, which were concerned with measuring constants. To this end, Sakharov and I visited HEL many times to discuss the conditions and results of experiments. However, HEL could not get permission to experiment with spherical models, and for this reason they experimented with flat models. In 1966 and 1967, I, together with I A Kurilov, graduate of the MSU Physics and Technology Department, and V N Mikhailov and V S Pinaev, graduates of Moscow Institute of Engineering Physics* (*MIEP*), *developed and introduced a number of improvements to the design of the RDS-37 hydrogen bomb. For this, in 1971, I was awarded the title of a Hero of Socialist Labor. All my life has been connected with KB-11* (*at present RFYaTs — VNIIEF*), *where I designed and improved hydrogen weapons*."

The Soviet Government generously gave awards to the people who developed the hydrogen bomb, and a number of awards was comparable to that for the first plutonium bomb. As mentioned earlier, "*for developing the RDS-6s gadget with a multilayer charge and for creating a basis for the theory of this charge*", Tamm and Sakharov were awarded the titles of a Hero of Socialist Labor and also became recipients of the Stalin Prize of the First Class; a bonus of 500,000 rubles was paid to each, while a ZIM limousine and a summer villa were presented to each free of charge, and during special missions their monthly salaries were doubled. Item 5 of the governmental resolution on Stalin Prizes of January 9, 1954 contained the name of the USSR Academy of Sciences Corresponding Member Ginzburg; he was awarded the Stalin Prize of the First Class "*for the suggestion of using lithium-6 in the RDS-6s gadget*" and paid a bonus of 100,000 rubles.

It must be noted that graduates of the MSU Physics Department Yu A Romanov (graduated in 1948), V B Adamskii and D V Shirkov (1949), the latter being worked in Bogolyubov's group, Yu N Babaev and L P Feoktistov (1950), and the graduate of the MSU Physics and Technology Department G A Goncharov and some others (more information about them can be found in the book *The Creators of Nuclear Weapons* [29]) actively participated in the development of the first hydrogen charge and its further improvements. Initially, Romanov worked in Tamm's group in the old building of the Physics Institute of the USSR Academy of Sciences on Miusskaya square in Moscow; later he moved to Arzamas-16, and still later he and Feoktistov were transferred to Research Institute No. 1011 (today the Russian Federation Nuclear Center — All-Russia Research Institute of Technical Physics (RFYaTs — VNIITF) in Chelyabinsk-70, presently the city of Snezhinsk), where they continued developing thermonuclear weapons. The interested reader can find more details about the work of Feoktistov and Romanov in Ref. [30]. The character reference of Feoktistov, first deputy scientific leader of VNIITF, contained in his personal file and signed by G Lominskii, the Director of the Center, V Tarasov, the CPSU City Committee Secretary, and M Voropaev, the CPSU Chelyabinsk Regional Committee Secretary, states [31]:

"*Already as a young scientist in the mid-1950s, he took part in a theoretical project that had to do with a new designing principle, which proved to be very productive and found wide application.*

*In his first years of work at VNIITF,* [*Feoktistov*] *initiated the development of an original project also related to an employment of a new physical process. Later, the results of the project not only were used in technological applications but also became a component part in designing a broad class of gadgets.*"

According to recollections of his colleagues, everybody who knew Feoktistov mentioned his high theoretical competence, his outstanding gift of invention, and his resourcefulness in solving complicated theoretical problems, combined with a critical approach to the results of his work. Lominadze [32] draws a very good picture of how Feoktistov fruitfully influenced the work of eleven graduates of the MSU Physics Department (G Filippov, A Filyukov, A Govorkov, V Gur'ev, A Khlebnikov, O Krokhin, D Lominadze, I Mikhailov, B Mordvinov, V Rozanov, and L Shibarshev), who graduated in 1955 and were sent to Research Institute No. 1011 (now RFYaTs — VNIITF) in Chelyabinsk-70, and of the creative climate in the researchers' collective. An indication of the confidence in the young graduates of the Physics Department is the fact that in the fall of 1955 a group of newly arrived physicists (B P Mordvinov and L I Shibarshev) and V S Imshennik (graduated in 1952) were sent on a mission to the test site. Many of the above group of physicists later became well-known scientists.

More details about the scientific activity of Tamm's group can be found in the book *Kapitza, Tamm, and Semenov in Essays and Letters* [33], in the memoirs of Sakharov [34] and Ginzburg [35], and in the numerous publications of research workers from KB-11, including Goncharov's detailed article [36].

In connection with the development of the plutonium and hydrogen bombs, mention should be made of another group of MSU graduates, headed by A N Tikhonov (graduated from MSU in 1927) and collaborated with KB-11 in calculating the processes that take place in explosions of atomic (plutonium) and thermonuclear charges. This group was established within the Geophysical Complex Expedition of the Geophysics Institute of the USSR Academy of Sciences. The group included A A Samarskii (graduate of the Physics Department of 1945), V Ya Gol'din (1948), B L Rozhdestvenskii (1951), N N Yanenko (graduated from the MSU Mechanics and Mathematics Department in 1945) and some others. As noted by Samarskii [37], at the beginning of 1948, during a seminar headed by Kurchatov, Tikhonov suggested doing a numerical calculation of an atomic explosion on the basis of complete models of physical processes (propagation of neutrons and heat, nuclear combustion, and gasdynamics) described by a system of nonlinear equation in partial derivatives, using the method of finite differences. As Samarskii later recalled, Landau, who was present at the seminar, assessed such a

calculation as a "heroic deed in science". Later on, MSU Rector I G Petrovskii, the future president of the USSR Academy of Sciences M V Keldysh (who graduated from MSU in 1931), and the well-known mathematicians K S Semendyaev and I M Gel'fand took part in such calculations. A detailed description of the events that took place in Tikhonov's group can be found in Ref. [37]. Below are excerpts from the evaluation of the contributions made by the groups of calculators, given in the above description of the 'Model' [28]:

"*The groups headed by Tikhonov and Landau developed mathematical methods needed for detailed calculations on the task orders of KB-11. Serious research and a big amount of work went into the methods. Twelve calculations of the possible gadgets* (*seven calculations in Tikhonov's bureau, three calculations in Landau's bureau, and two calculations in the Semendyaev–Gel'fand bureau*) *were done in the search for the optimal variant of RDS-6s and the methods of exploration*.

*Several essential issues should be mentioned. A method of calculation was selected in which the small errors, inevitable in such cumbersome computations, do not build up and cannot lead to large errors in the final result. Solution of this problem paves the way to using electronic computers instead of slow and cumbersome manual counting*.

*The presence in the gadget of shock waves generated by the compression of the light layers in the nuclear explosion and caused by the layered structure of the gadget posed very serious difficulties in the problem of calculating the RDS-6s gadget* (*the difficulties were overcome by Landau as late as 1952*)."

For their outstanding achievements, Tikhonov was twice awarded the title of a Hero of Socialist Labor, and his close associates Samarskii and Yanenko were awarded the title of a Hero of Socialist Labor, and both were elected Full Members of the USSR Academy of Sciences.

Another group at the Physics Institute of the USSR Academy of Sciences that actively worked on Kurchatov's task orders was established at the department headed by I M Frank, who graduated from the MSU Physics Department in 1930 and later became an academician and a Nobel Prize Winner in Physics. We know of Kurchatov's memorandum written for M G Pervukhin on May 26, 1944 on recruiting researchers from the Physics Institute, including Frank, for work "*on the problem*" [38] (later Frank studied the processes associated with the passage of neutrons through matter, together with E L Feinberg, a graduate of the MSU Physics Department of 1935). As a result of the discussion of Tamm's report covering the 'sloika' project at a session of the Scientific and Technical Council of Laboratory No. 2 on December 2, 1948, Frank's group from the Physics Institute was charged with the task of conducting experiments in neutron multiplication in a system consisting of heavy water and uranium. Frank's group was released from all other work — so important were these experiments considered as compared to other projects. Frank was a professor at the MSU Physics Department and read lectures in neutron physics to the students of the Division of the Structure of Matter, of which I was also a student. He delivered his lectures in a low voice, possibly because of his weak health, although this could simply be a false impression. He formulated the basic ideas very distinctly and his lectures, as we (his students) found out later, helped us greatly in our independent research.

Finally, the last example has to do with O A Lavrent'ev, graduate of the MSU Physics Department of 1955, with whom I studied in the same group of students. In the late 1940s and early 1950s Lavrent'ev served in the 221st Separate Antiaircraft Battalion on Sakhalin Island in the Soviet Far East. According to his memoirs [39a], "*the idea to use thermonuclear fusion first came to me in the winter of 1948*". A detailed history of Lavrent'ev's proposal can be found in Ref. [39b].

Lavrent'ev's proposal was sent to Sakharov, who wrote a referee report [40], which he signed no later than August 18, 1950. In his report, Sakharov pointed out, among other things, that

"*I believe that we need to organize a detailed discussion of Cde. Lavrent'ev's project. Regardless of the results of the discussion, it is necessary at this point not to overlook the creative initiative of the author*."

We cannot exclude the possibility that it was Lavrent'ev's idea of thermonuclear fusion that prompted Sakharov to carry out calculations on a magnetic thermonuclear reactor with magnetic confinement of plasma instead of electrostatic field confinement, as proposed by Lavrent'ev. This assumption is corroborated by Beria's memorandum of January 15, 1951. Beria charged B L Vannikov, A P Zavenyagin, and Kurchatov with the important mission of organizing research focusing on a magnetic thermonuclear reactor by forwarding them a (one-page) instruction note in which, among other things, he mentions Lavrent'ev's proposals [40]:

"*Incidentally, we must not forget the MSU student Lavrent'ev, whose memo and proposals gave impetus, according to Sakharov's report, to developing a magnetic reactor* (*Cdes. Pavlov and Aleksandrov of the Main Directorate have received Lavrent'ev's memo*).

*I had a meeting with Cde. Lavrent'ev. As I understand, he is a capable young man. Call him in, hear him out, and together with Cde. Kaftanov do everything possible to help Cde. Lavrent'ev in his studies and, where possible, in his participation in the work. Execute within five days*."

Exactly on time, on January 20, 1951, Vannikov, Zavenyagin, Kurchatov, and N I Pavlov reported to Beria [42]:

"*By Your charge, today we called in to the First Main Directorate O A Lavrent'ev, a first-year student of the MSU Physics Department. During the conversation, Lavrent'ev briefly described the essence of his proposal and expressed the wish to continue the study in the direction of interest to him*."

At the end of the letter, the authors report that all the suggestions have been coordinated with V S Kaftanov and ask Beria to approve them and that suggestions on Lavrent'ev's participation in the work of the Laboratory of Measuring Instruments will be presented later. The letter bears Beria's mark "*Approve*".

A brief digression is in order here. Lavrent'ev's fate is unique in the history of the Soviet Atomic Project. The top leaders of the Soviet State and the atomic industry were involved with personal matters of Lavrent'ev's life at this point, such as his well-being and education, assigning him a fully furnished room with a library accumulating technical literature. True, this was not the first case when a young specialist was provided with an accommodation unit. One of the items in the first resolution concerning the hydrogen-bomb project mentions assigning a room for Sakharov's family (which pleased him very much, as he remembered). And yet there is one unclear question relating to the fact that Lavrent'ev was freed from all payments for his studies at Moscow State University, although nobody paid for such

studies. Naturally, Lavrent'ev did not tell the students about the work he was doing in his 'free' time nor about his plans, and certainly not about the meetings with the highest ranking leaders of the Atomic Project. However, his appearance was such that you could be sure he was constantly a very busy man. He was very diligent in his learning. On March 2, 1951, the same group of leaders sent a letter to Beria containing a suggestion, coordinated with D I Blokhintsev, Director of Laboratory 'V', to establish in Laboratory 'V' a small group of researchers to study the project of a magnetic thermonuclear reactor and to attach Lavrent'ev to this group [43].

However, after graduating from MSU, Lavrent'ev was not invited to work at KB-11 nor at the Laboratory of Measuring Instruments of the USSR Academy of Sciences. He was assigned to a job in the Khar'kov Physical-Technical Institute and became involved in studies of thermonuclear reactions. For more details about Lavrent'ev's fate, the interested reader can turn to Ref. [39].

Graduates of the MSU Physics Department and Physics and Technology Department (the latter was reorganized into the Moscow Institute of Physics and Technology, or MIPT) worked at almost all research institutes and facilities involved in the Atomic Project. Some of them head well-known physics institutes. For instance, E P Velikhov (graduated in 1956) heads the Russian Research Centre 'Kurchatov Institute'; P A Aleksandrov (1967) is at the head of the IT Institute of the Russian Research Centre 'Kurchatov Institute'; S T Belyaev (graduated from MIPT in 1952) is at the head of the Institute of General and Nuclear Physics of the Russian Research Centre 'Kurchatov Institute'; E P Ryazantsev (1954) is at the head of the Institute of Reactor Technologies and Materials of the Russian Research Centre 'Kurchatov Institute'; V G Kadyshevskii and A N Sisakyan are at the head of the Joint Institute for Nuclear Research. Directors of institutes were A A Logunov (graduated in 1951), Institute of High Energy Physics; O N Krokhin (graduated in 1955), Physics Institute of RAS; V D Pis'mennyi (graduated in 1956), Russian Federation State Scientific Center 'Troitsk Institute of Innovation and Thermonuclear Research', and R Z Sagdeev (graduated in 1955), Institute of Space Research of the USSR Academy of Sciences. A list of outstanding scientists that graduated from the MSU Physics Department and contributed greatly to the building of the atomic industry and to the development of science can be continued; this topic obviously requires further study. It must be also noted that in addition to physicists a large number of graduates of the Biology, Geology, Mechanics and Mathematics, and Chemistry Departments of MSU worked at research institutes and facilities that were empowered to accomplish the works for the First Main Directorate.

## 6. Conclusion

On December 2, 2004, the congress of Moscow State University alumni opened in the MSU Assembly Hall. The graduates of various departments met at their departments on December 3, too. Many speakers at the congress mentioned the great contribution of the graduates and scientists of MSU to developing society, higher education, the natural sciences, and the humanities. They also remarked on the high level of instruction that MSU provides and that makes it possible for its graduates to be well-equipped for their voyage across the sea of unknown phenomena. It goes without saying that only a fundamental university education made it possible for MSU graduates to solve important state, technological, and scientific problems brought together in the Soviet Atomic Project. We can be sure that future graduates will carry on the traditions of Moscow State University.

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