The USSR Academy of Sciences: 250 years

Usp. Fiz. Nauk 113, 3–28 (May 1974)

In this month of May, 1974, the USSR Academy of Sciences is observing the 250th Anniversary of its founding. A resolution of the Central Committee of the Communist Party of the Soviet Union stresses the exceptionally important role that the Academy of Sciences has played and continues to play in the life of our country.

It is, of course, impossible to present a halfway detailed or disciplined historical analysis of the events associated with the creation of an Academy of Sciences in Russia within the scope of a single article that must cover such a long span of time.

In addressing ourselves to the history of the Academy from its origins, it nonetheless appears helpful to dwell at least briefly on certain aspects of the period leading up to its birth and to review, in a few lines, the initial period of its existence, which determined the subsequent course of events in many respects.

First of all, we should note the beneficent role of Peter I, thanks to whose efforts the Russian Academy of Sciences got off to a vigorous start. After Peter's death, there was some loss of this initial forward impetus, but that which had been set in motion was neither to stop nor to turn back.

The growth of Russian military might and the development of Russian industry could have taken place only on a firm foundation of education and science. The last years of the reign of Peter I were marked by imposing progress in this direction. Geographical discoveries, the survey and development of the natural wealth of Russia, especially in the Urals and Siberia, the creation of a strong foundation for shipbuilding and metallurgy, the opening of inland waterways—all of these things attested eloquently to the need for development of science in the country and posed the problem of creating an Academy of Sciences and a University in Russia, of training (to use the modern idiom) a national scientific cadre.

There are numerous direct proofs of Peter's interest in the future Academy: he discussed the question of its creation with his contemporaries as early as 1698, shortly after his return from Europe. On his journey, Peter had made the acquaintance of noted scientists of that time—van Leeuwenhoek, Newton, and others.[1)] In a congratulatory message to the USSR Academy of Sciences on its 220th anniversary two and a half centuries later from the Royal Society at London, it was observed specifically that "The Royal Society is pleased that the founding of the Academy of Sciences in 1725 was in some measure the result of impressions gained by the Czar Peter the Great during his visit to England in 1698 and, in particular, of the friendly relations that he established with certain prominent members of the Royal Society."

At the beginning of the Eighteenth Century, Peter I corresponded with the great Leibnitz and discussed the future Academy with him. Their personal meeting at the end of 1711 was a historical milestone. A number of conversations on the subject of the Academy took place during a short subsequent period. For four years Leibnitz was even in the Russian service as a Privy Councillor of Justice. He wrote Peter in January of 1712: "...My thoughts are directed toward the welfare of the entire human race, because I consider the heavens my country and all thoughtful men my countrymen, and I should rather do much good among Russians than little among the Germans or other Europeans."

This attitude was typical of many (but not all) of the academicians invited to work in Russia, and we are correct in numbering, for example, the great Euler among our countrymen, as he did himself, regarding Russia as his second homeland, in which he worked for more than 20 years. (Euler died and was entomed at St. Petersburg, in the Alexander Nevskiĭ Monastery).

In 1717, during a stay in France, Peter made a strong impression on the members of the Parisian Academy and was soon elected one of its foreign members. He wrote the President of the Academy, Abbot Vignon, on February 11 (22), 1721: "By the grace of God, we, Peter the First, Czar and Autocrat of all the Russians, etc., etc., etc., offer our warmest compliments to the Royal French Academy of Sciences. It could have given us nothing but the greatest pleasure to hear that you have elected us a member of your company. We did not wish to depart without expressing our appreciation to you and assuring you that we accept the place that you have presented to us with great satisfaction and that we wish nothing more than to prove ourselves a worthy member of your company by the diligence with which we shall seek to bring the sciences into the best light. We have instructed our first royal physician Blumentrost to report from time to time on what is new in our governments and our lands and what is worthy of consideration by the Academy, and we should be most pleased if you would hold correspondence with him and from time to time advise him in turn of what new discoveries are forthcoming from the Academy."

At about this time, Peter's activity toward the founding of an Academy of Sciences began to acquire steadily sharper definitions, and his ideas were embodied in specific measures.

As we know, Peter trained national scientific cadre by sending Russian youth to study abroad. He charged his librarian Schumacher with a special task: that of acquiring books on mechanics, physics, and mathematics. (Peter himself, as a rule, imported books, collections, and various instruments from abroad, displaying them in the Kunstkammer that he had founded).

There were very few learned persons in the Russia of the first quarter of the Eighteenth Century, and one of the brightest and best-educated was the historian and geographer V. N. Tatishchev. In his "Conversation of Two Friends on Science and Schools," Tatishchev conveyed the content of the following conversation between himself and Blumentrost, which Peter also joined: "In 1724, when I was preparing to depart for Sweden, I chanced to be with His Majesty in the summer house; on this occasion, Royal Physician Blumentrost, as President of the Academy,[2)] told me to seek out learned persons in Sweden and invite them to the new Academy as Professors. I burst out laughing, and replied that he wanted to build a very powerful Archimedean machine when there was nothing to lift and nowhere to put it. His Majesty deigned to ask what I meant, and I replied that he was seeking teachers when there was no one to teach, because without lower schools this Academy would be useless no matter what expense he went to. To this His Majesty was pleased to reply as follows: I have a great harvest to mill, but there is no mill; I want to build a water mill, but there is no water nearby; there is water at some distance, but I may not have time to build a canal because life is uncertain; but if I first commence to build the mill, and if I command that the canal only be started, my heirs will be better compelled to bring water to the finished mill.''[3)]

Among the most enlightened men of Peter's time were Prince A. D. Kantemir and his clerical instructor Feofan Prokopovich, who also tutored Tatishchev. However, there were neither mathematicians nor physicists in Russia, and Peter commisioned his Royal Physician Lavrentiĭ Blumentrost to invite major scientists who had one European recognition for there research in the natural sciences to come to Russia to work. Blumentrost was assisted in this effort both by German scientists—notably C. Wolff (the future teacher of Lomonosov) and by Russian government officials and diplomats. Blumentrost was also entrusted with drafting the Academy of Sciences Statute (Charter), which was presented to Peter in January of 1724 and preserves corrections and addenda that Peter made in the margins.

It would be appropriate here to present a brief historical outline of the basic changes that have taken place in the Statute (By-Laws) of the Academy of Sciences, in its naming and in its academic titles to the present day.

The Academy Statute approved by Peter I in 1724 was drawn up in recognition of the specific condition of the Russian state, in which there were no universities through the end of the first quarter of the Eighteenth Century. Thus, unlike the models that Peter I might have observed during his foreign travels, his Academy was a unified complex that had no analogs, including secondary (Academic Gymnasium) and higher (Academic University) schools and the Academy proper—what we would now call the scientific-research establishment.

Young people from among the most capable University graduates were chosen to be Adjuncts of the Academy, a status referred to as "continuation for preparation for academic activity" (in much the same way as the most capable students of the prerevolutionary period, those who graduated from the university magna cum laude, were kept on at the university "for preparation for professorial titles"), which led to the Academic Chair. The first of these chairs were awarded to foreigners.

The activity of Academy members was regulated as follows by this document: "whereas the Academy is nothing other than a society (assemblage) of persons whose purpose is to assist one another in the promotion of the sciences, it is most needful to this end that they meet once a week for several hours so that each member can present his opinion, benefit by the advice and opinion of the others, and verify his experiments in all particulars in the presence of all members. And this last will be most useful so that in such experiments one member may call upon another, as, for example, the anatomist, the mechanic, etc., for a thorough demonstration."

The Elizabethan By-Laws (1747) also regulate the work of Academy members: "Academic meetings are to be held three times a week. At each session, each member, beginning with the senior academician, will read his inventions before the others from 9 to 12 o'clock. If a dissertation is not completed in one session, it will be continued at the next session and not put off to the next round."

It was directly evident from the By-Laws that the Academy members had to reside at St. Petersburg.

A few remarks follow on the evolution of the name of the Academy itself and the academic titles.

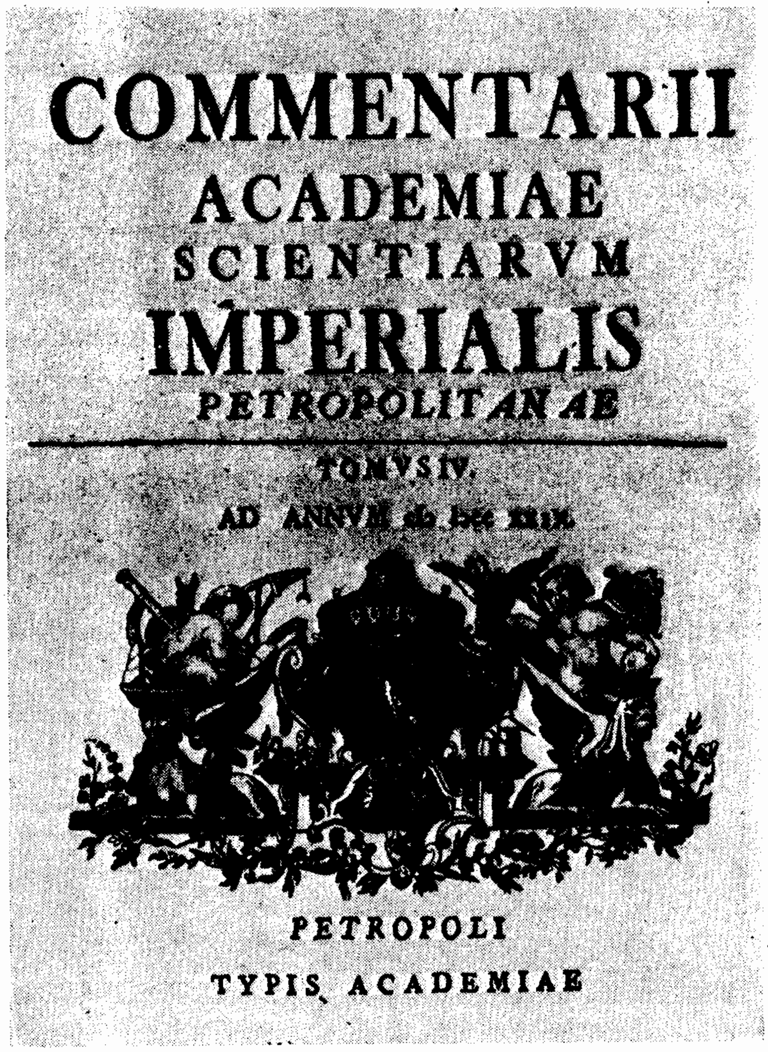
It was originally called the "Academy of Sciences and Arts" the term "Arts" implying, as a rule, both the workshops and all of the possible applications that might come out of "theoretical" discoveries and investigations. The academic workshops and other practical establishments in the Academy were segregated in 1757 into the Academy of Arts, which became independent of the rest of the Academy. In the 1747 By-Laws, the Academy is named the Imperial Academy of Sciences and Arts; after separation of the Academy of Arts, it also appears under the title "St. Petersburg Academy;" in the 1803 By-Laws, the "Imperial Academy of Sciences" is mentioned. In 1783, the "Russian Academy of Sciences" (or the Academy of Russian Language and Belles-Lettres) was formed in independence from the "Main" Academy; one of its members was A. S. Pushkin. In 1841, it was attached to the Imperial Academy and merged into a single entity with it. At a commemorative meeting on December 29, 1917, the entire Academy was renamed the "Russian Academy of Sciences," and, finally, it acquired its present name in June of 1925.

As we noted above, the original Statute provided for the titles of Academician, Adjunct, and (University) Professor in the Academy. Active members could also be University Professors and were, in principle, allowed to undertake other paid obligations. However, the 1724 "Statute" includes cautionary lines on this matter: "if an Academician wishes to hold paid private positions, he may do so, But it is not appropriate for him to hold very many positions solely for the sake of gain, to the detriment of his other sciences and reflections..." as we see, the struggle against plurality of offices has been a traditional one for the Academy of Sciences.

Honorary Academicians were instituted beginning (approximately) in 1731; at first, this title was given Academicians who had left the walls of the Academy and returned home or transferred to government service for one reason or another. Distinguish persons and government officials, both foreign and Russian, could also be elected Honorary Academicians.

In 1759, at the suggestion of M. V. Lomonosov and others, the title of Corresponding Member of the Academy was introduced; it could be held by persons who, though "not having the knowledge required of a proper member, might nevertheless serve the Academy with notes and reports of news."[4)]

Later, the By-Laws of 1803 instituted the title of Extraordinary Academician—a rank between Adjunct and Ordinary Academician (Active Member). The same



Title page of the "Commentaries" of the Academy of Sciences with the emblem used in Vols. II through XIV of this publication. A fruit tree appears at the center of the emblem, and above it the inscription "Paulatim," i.e., "Gradually" or "Bit by Bit."

By-Laws provided for the acceptance of "Pupils of the Academy" into the staff; after successfully passing their examinations, these persons were sent abroad for further education in the sciences. Each pupil was assigned to a specific Academician. The pupil status was eliminated by the By-Laws of 1837, and the titles of Adjunct and Extraordinary Academician were abolished in 1912.

According to the first By-Laws adopted during the Soviet period, those of 1927, "The Academy of Sciences of the USSR consists of Active Members (Academicians), Honorary Members, and Corresponding Members and scientific personnel;" at the present time, of course, our Academy confers the titles of Active Member and Corresponding Member on Soviet scientists and Foreign Member on foreign scientists.

The first physicists at the academy. The organization of physical research in the newly created Academy was perfectly natural. By the beginning of the Seventeenth Century, physics already had a history of its own that glittered with names of undying lustre (Galileo, Huygens, Newton), had achieved major results, especially in mechanics and optics, and was influencing the development of the technology of the day and the related sciences.

S. I. Vavilov, then President of the USSR Academy of Sciences, a noted Soviet physicist, and a profound historian of science, wrote in 1946 about the first academician-physicists of the newly founded Academy. The article, which was published in this journal (28, p. 3) conveyed the content of a paper that had been read at a commemorative session of the Scientific Council of the P. N. Lebedev Physics Institute of the Academy on the occasion of the Institute's 220th anniversary. This paper and the Vavilov article traced the successorship relation between the Physics Cabinet of the Academy of Sciences and Arts (1725) and the FIAN through the Physics Laboratory of the Imperial Academy of Sciences (1912).

The first director of the Physics Cabinet was Academician G. V. Bulfinger. "At the Petersburg Academy, he showed himself to be a many-sided experimental physicist. The results of his experiments were published in numerous articles in the "Commentaries."[5] The experiments are concerned with sensitive barometers and the most suitable form for

Academician Mikhail Vasil'evich Lomonosov (1711-1765).

them, quantitative laws governing the rise of liquids in "fine-bore" tubes, air pumps, and measurements of friction." Further on, Vavilov notes that "Academician Bulfinger was by no means alone in the new Academy."

Since there were no learned physicists in Russian at the beginning of the Eighteenth Century and no universities that prepared scientific cadre, the first of its physicists were invited from abroad to serve as members of the Academy. First mention among them is accorded to Daniel Bernoulli (1700–1782) and Leonhard Euler (1707–1783). Bernoulli made a major contribution to the development of hydrodynamics, mechanics, and acoustics; in particular, he derived the equation of state of the ideal gas from kinetic considerations. Euler, who at one time occupied the Chair of Physics at the Academy, is known in the history of science primarily for his numerous and brilliant mathematical papers. In the article cited above, Vavilov wrote of him that "Euler's physics shine, of course, in the light of his mathematical glory, but in the Eighteenth Century it was in itself perhaps the most systematic extant, and is worthy of much closer attention than has ever been given it. Despite the errors of Euler's wave optics (...), it paved the way for the optics of Fresnel... The 'Letters to a German Princess,' was a tremendously popular Eighteenth Century Encyclopedia of Physics that was full of original ideas. Many generations of Russians studied physics in the excellent Russian translation of these 'Letters' prepared by Academician Rumovskiĭ, a student of Euler."

Systematic researches in optics were developed in the Academy from the very start of its activity. They were continued at the Academy throughout the entire Eighteenth Century by Euler, Lomonosov, Epinus, Kulibin, and others. Their originator was I. G. Leutman (1667–1736), who set up the workshops in which skillful Russian masters polished lenses with parabolic surfaces and built telescopes and other optical instruments. The tradition of pursuing optical researches in the Academy has come down to us on an expanded scale.

The attention of the first Academicians was drawn to a science that was young in their day: that of electrical phenomena, with emphasis on investigations on atmospheric electricity, which was of enormous practical as well as theoretical importance. The studies of Academician G. V. Richman (1711–1753) (jointly with M. V. Lomonosov) were begun even before Franklin's famous experiments. As we know, Rikhman died tragically when he was struck by lightning during an experiment. Richman's studies in calorimetry were less well-known, but no less significant.

The career of M. V. Lomonosov (1711–1765) marked a new epoch in the history of Russian Science. He was one of those rare exceptions—a talented diamond in the rough who came out of the backwoods of the nation to rise to the academic heights that were in those bygone days the preserve of members of the upper strata of society or of celebrated foreigners. We, as physicists, regard Lomonosov primarily as a physicist or physical chemist. And this is understandable: his name is associated with enunciation of the law of conservation of matter in chemical reactions and with the general idea of conservation of motion, the development of kinematic conceptions of the structure of matter, the nature of heat, and studies of atmospheric electricity. Lomonosov was an encyclopedically educated scientist who worked productively in many areas of science and engineering: he was an astronomer and a geologist, a geographer and a cartographer, a specialist in metallurgy and mining, and inventor and the constructor of a number of optical instruments. But Lomonosov left his mark even in the humanities: he developed the foundations of a theory of a Russian language and wrote treatises on historical questions. He emerges at the same time as a scientific organizer. Like no one else he understood the importance of providing training for native scientific cadre. By way of solving this problem, he came forth as the driving force and founder of the Moscow State University that now bears his name. From that time on, the preparation of native scientific cadre has had a solid basis.

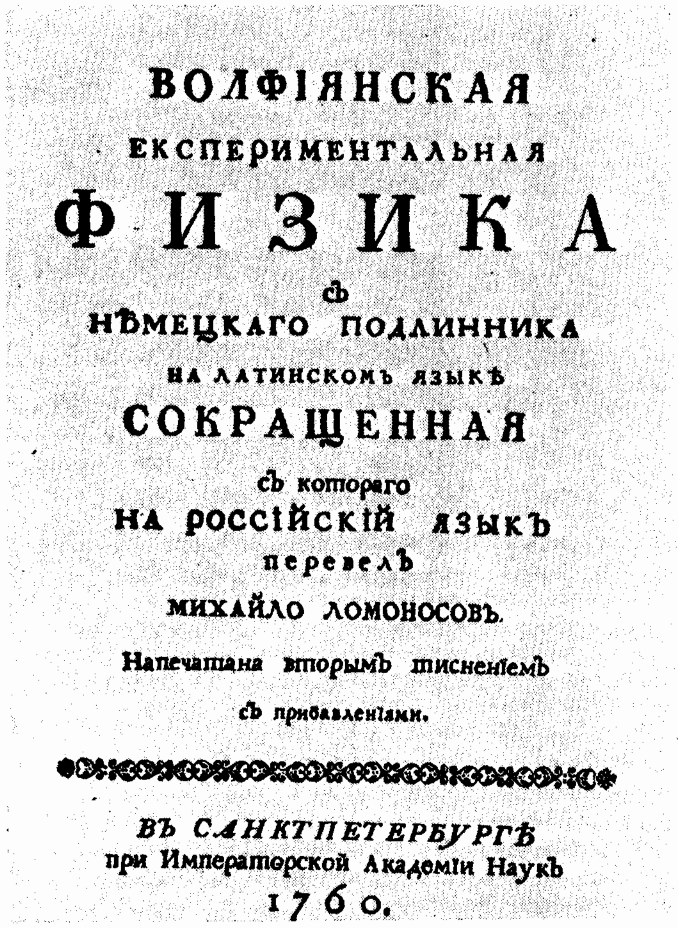
But Lomonosov was more than an encyclopedist and scientist who advanced ideas that were new for his time in many fields of science. He was an artist (Lomonosov's mosaic portrait of Peter I is a widely known example) and a talented poet who celebrated the nature and achievements of science. Circumstances conspired to make Lomonosov's poetic works widely known in Russian society, while his scientific investigations, which were printed in Latin in occasional publications, were difficult of access and half-forgotten. We are indebted to Prof. B. N. Menshutkin for translating them, with commentaries, early in our Century, thus "rediscovering" Lomonosov as a scientist for the scientific community.[6]

Leonhard Euler, Mikhail Lomonosov—their names are inseparably connected with the origins of science in Russia, a matter of which the Academy of Sciences is justly proud.

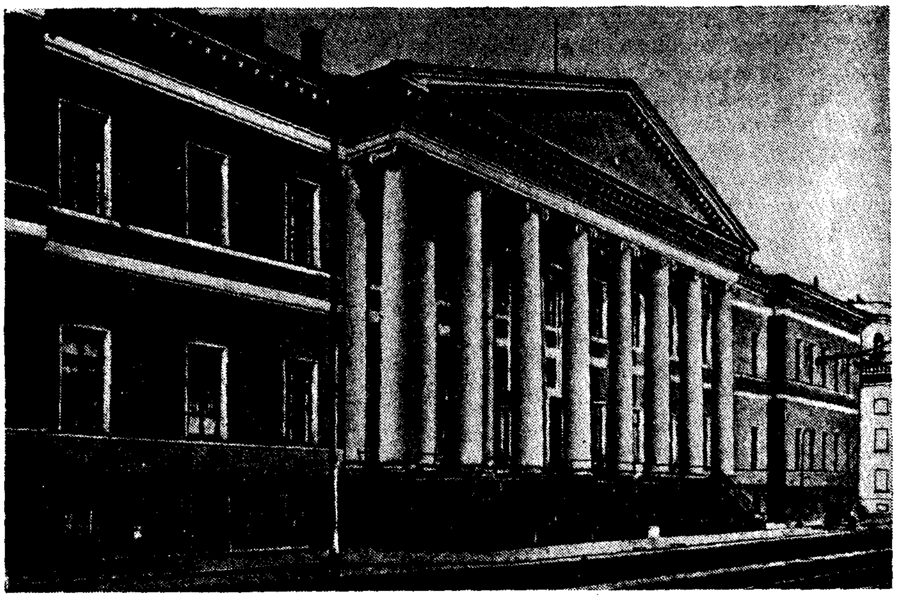
Investigations of electric current occupied a significant position in physics during the Nineteenth Century. In this area too, the academician-physicists—V. V. Petrov (1761–1834), H. F. E. Lenz (1804–1865), B. S. Jacobi (1801–1874)—enriched science with brilliant achievements and distinguished themselves as worthy representatives of the "Century of Electricity." Petrov devised sources of high-voltage current, discovered the electric arc, and investigated electrical discharge phenomena in gases. Lenz investigated the loss of excitation of induced currents, the heat effect of currents, and the temperature dependence of the resistance of metals: "Lenz's rule" and the "Joule-Lenz law" are terms familiar to everyone from his schooldays—a kind of index to the fundamental quality of these studies. Jacobi's works on galvanoplastics, electric motors, and wire telegraphy were of great applied significance.

It is not possible in this brief review to discuss these studies in greater detail.

The academy of sciences and physics in prerevolutionary Russia. In the Nineteenth and early Twentieth Centuries, Physics developed in Russia for the most part in the higher educational institutions. Prominent and talented physicists, heads of departments and laboratories made their appearance in these schools. As a rule, however, they found themselves beyond the pale of the Imperial Academy of Sciences. The autocratic regime did not understand the importance of science for the development of industry and agriculture, and feared that the democratic spirit might penetrate within the walls of the Academy. It placed every conceivable obstable in its path. Administrative arrogance took root in the conduct of the Academy's affairs. Although Peter's 1724 "Statute" had provided for election of the President, the first President (Blumentrost) was actually appointed by Catherine I. This practice was then written into the By-Laws of the Academy as issued under Elizabeth in 1736, Alexander in 1803, and Nicholas in 1836, remaining in force for almost a century. The appointed presidents were nearly always loyal servants of the regime who were known for their editorial views, or representatives of the aristocracy. It is sufficient to recite the names of S. S. Uvarov (in office from 1818 to 1855), D. N. Bludov (1855–1864), who played an ignominious role in the condemnation of the Decembrists, D. A. Tolstoĭ (1882–1889), who held the positions of Minister of Internal Affairs and Chief of Police as sidelines, or the Grand Duke Constantine of the house of Romanov (1889–1915). Academician Petrov, a plebeian who openly criticized the disorder in the Academy, was


ВОЛФІЯНСКАЯ
ЕКСПЕРИМЕНТАЛЬНАЯ
ФИЗИКА
съ
НѢМЕЦКАГО ПОДЛИННИКА
НА ЛАТИНСКОМЪ ЯЗЫКѢ
СОКРАЩЕННАЯ
съ котораго
НА РОССІЙСКІЙ ЯЗЫКЪ
перевелъ
МИХАЙЛО ЛОМОНОСОВЪ.
Напечатана вторымъ тисненїемъ
съ прибавленїями.
ВЪ САНКТПЕТЕРБУРГѢ
при Императорской Академїи Наукъ
1760.

Title page of the Second Edition of the "Wolffian Experimental," translated by M. V. Lomonosov. This edition contains addenda with a brief exposition of Lomonosov's own physical memoirs.



Main building of the USSR Academy of Sciences at Leningrad.

expelled from it in 1827 by President Uvarov after a collision with him. Duke Romanov excluded A. G. Stoletov from the balloting in 1893.

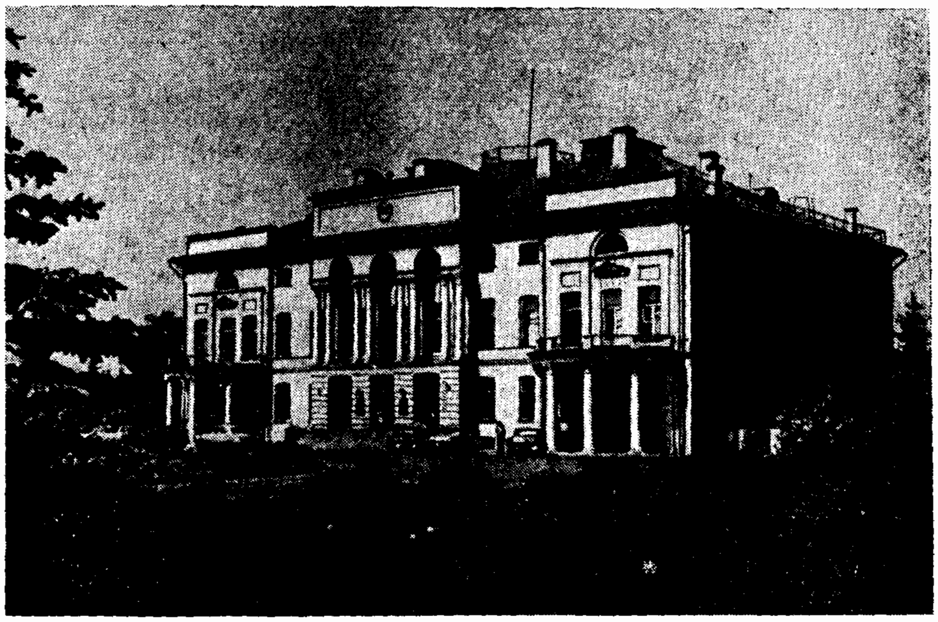
The fate of E. S. Fedorov (1853—1919), who laid the theoretical foundations of present-day crystallography, is quite typical as an illustration of the high-handedness that prevailed. He was already a noted scientist and the author of numerous investigations, including the famous work "Symmetry of Regular Systems of Figures" (1891), in which he investigated crystalline structures (establishing 230 of them) and found their geometrical laws, when he was blackballed at the elections to the Academy in 1893. No amount of scientific merit could move the Czarist government to forget his past revolutionary connections (Fedorov had been a member of the "Land and Freedom" party and one of the editors of its newspaper). He had already authored scores of major scientific papers, invented special instruments and research methods, and been named to many foreign Academies and scientific societies when approval was finally given (in 1901) to the election of the 48-year-old scientist as ... an Adjunct, i.e., an apprentice scientist. But even as a Member of the Academy, he encountered insurmountable obstacles on the path to his scientific objectives: his plans for organization of a Mineralogical Institute were either ignored or rejected, and this forced him to issue a declaration, on January 5, 1905, to the effect that there was no point in his remaining in an Academy that gave scope not to "modest men of science" but to "important representatives of our bureaucracy, which has put forth the Birons, the Arakcheevs, Dmitrii Tolstoĭ, and Pleve as its outstanding representatives." Not until the Soviet time arrived, in 1919, was Fedorov made a member of a renewed Academy of Sciences.

It should come as no surprise that many prominent physicists of the prerevolutionary era worked outside of the Academy of Sciences—N. A. Umov, A. G. Stoletov, A. S. Popov.[7] Nor was Petr Nikolaevich Lebedev (1866—1912) an Academy Member, even though his researches, which had led to the discovery of light pressure, had been enthusiastically acknowledged in our country and abroad as a model of profound theoretical thought and subtle experimental skill. Another of Lebedev's services to Russian Science was his creation of a major school of physicists that made a tremendous contribution to the development of physics and the training of scientific cadre in the new centers that were set up after the Revolution. There are other famous names among the successors and students of the Lebedev school: for example, P. P. Lazarev, S. I. Vavilov, V. K. Arkad'ev, T. P. Kravets, S. N. Rzhevkin, and É. V. Shpol'skiĭ.

At the beginning of the Twentieth Century, Academician B. B. Golitsyn (1862—1916) moved to the directorship of the Physics Cabinet of the Academy. As a result of his efforts, the Cabinet was expanded, equipped with first-class instruments, secured a small staff, and was transformed into the Physics Laboratory. Golitsyn did pioneering work in seismology, designed measurement instruments, and organized a network of seismic stations. Later, under the Soviet regime, the Seismological Institute was created on the base that had been developed for it.

The Academy of Sciences in the early years after the revolution. After the Great October Socialist Revolution, the position of the Academy of Sciences in the country changed abruptly. Control of the government came into the hands of a party whose reforming, social, and economic activities are rooted in science. It was natural that the Soviet Government and its leader, Vladimir Il'ich Lenin, would call upon the Academy of Sciences to solve the monumental problems of the country's economic and social development.

At an extraordinary General Assembly of the Academy of Sciences on January 24 (February 6), 1918, its Permanent Secretary, Academician S. F. Ol'denburg, reported that he had discussed the prospects opened for the Academy of Sciences by the Revolution with representatives of the Soviet Authorities. Projects were envisaged within the framework of expanded activity of the Commission to Study the Natural Productive Forces of Russia (KEPS), which had been organized in the Academy in 1915. In a letter to a A. V. Lunacharskiĭ the People's Commissar of National Education, Academy



Presidium building of the USSR Academy of Sciences at Moscow.

of Sciences President A. P. Karpinskiĭ wrote on March 5, 1918, that the Academy stood ready to collaborate with the Soviet Government both in study of the country's natural resources and with analyses of a technical-economic nature—in order to aid in selection of the best ways to ensure rapid progress in the most important branches of the country's economy, industry and agriculture. Energy problems were an important part of these plans, which called for utilization of the energy of rivers, finding cheap fuel sources, the opening of new waterways, and irrigation and melioration projects. It was proposed that all of these problems be solved in the new institutes and laboratories being set up under the Academy of Sciences.

The activities of the Academy of Sciences during the Soviet period were defined by Lenin's celebrated "Outline Plan for Scientific and Technical Projects" (April, 1918), which was addressed to the Academy. Under this plan, the Academy of Sciences was called upon to perform economic and engineering research of prime national importance (rational siting for industry, electrification of transport, industry, and agriculture, use of water power and wind engines).

A characteristic reflection of the Academy's organizational efforts was the opening at Moscow of a division of the Commission to Study the Natural Productive Forces of Russia, which included roentgenology, thermometry, photometry, photochemistry, and wireless-telegraphy divisions and five others with missions in animal husbandry, agriculture, and general problems in the study of labor productivity; the Academy also became involved in the economic research dictated by the new management and planning system. This took place in mid-1918, and at the end of the year a Scientific Commission chaired by Academician P. P. Lazarev was organized in the Supreme Council of the National Economy (VSNKh).

On January 27, 1921, Lenin received delegates from the scientific and educational institutions of Petrograd—S. F. Ol'denburg, Permanent Secretary of the Academy, and V. A. Steklov, its Vice President. Problems of "support for scientific-research projects in the Soviet Republic" were discussed. Ol'denburg later set down in writing his unforgettable impressions of this meetings with the leader of the revolution.

One of the problems confronting the Academy during the early phase of its reorganization (1918—1921) and implementation of the broad program set forth in the documents of the Soviet Government that were addressed to the Academy was to close, as quickly as possible, the information gap that had resulted from the interruption in the exchange of scientific information. The first World War and the Civil War that followed it has interrupted for 6—7 years the quite regular communications that had been kept up between native and foreign science via exchanges of journals and people. Collections entitled "New Ideas in Physics," "New Ideas in Astronomy," etc. had appeared regularly in prerevolutionary Russia since the beginning of the second decade of this Century; they had printed reviews written by major scientists (native and foreign) on the latest achievements of physics, astronomy, and mathematics. Such reviews were also printed in the "Problems of Physics," a journal attached to the Journal of the Russian Physicochemical Society.

The first party of Soviet scientists had been sent abroad back in 1918 (to purchase books, journals, and instruments); a group of ten (including three Active Members of the Academy of Sciences) were sent abroad in 1920; the task of acquiring physics literature was given M. I. Nemenov, one of the organizers of the Physicotechnical Institute (which was known at the time as the State Roentgen and Radiological Institute). In 1921 A. F. Ioffe, P. L. Kapitza, A. N. Krylov, and D. S. Rozhdestvenskiĭ visited Germany, England, Holland, and France.

Soviet diplomats, especially L. B. Krasin, also played a major role in the establishment of contacts.

As a rule, the missions of the Soviet scientists received full support from their European colleagues—the assistance rendered the Soviet physicists by H. A.

Lorentz, P. Ehrenfest, and E. Rutherford is well known. We reproduce here a letter from A. Einstein (dated early in 1921) to N. M. Fedorovsskiĭ, President of the Scientific and Engineering Division of the Supreme Council of the National Economy (it was published in the newspaper "Izvestiya" on January 27, 1921):

"I have heard from our friends that the Russian comrades are engaged in intensified scientific research even under the present circumstances."

"I am quite convinced that to offer assistance to our Russian colleagues is both a pleasant and a sacred duty of all scientists who find themselves under more favorable conditions, and that the latter will do everything in their power to restore international communications."

"I shall welcome the Russian comrades warmly and promise to do everything that I can to establish and maintain communications between scientific workers here and in Russia." (signed—A. Einstein).

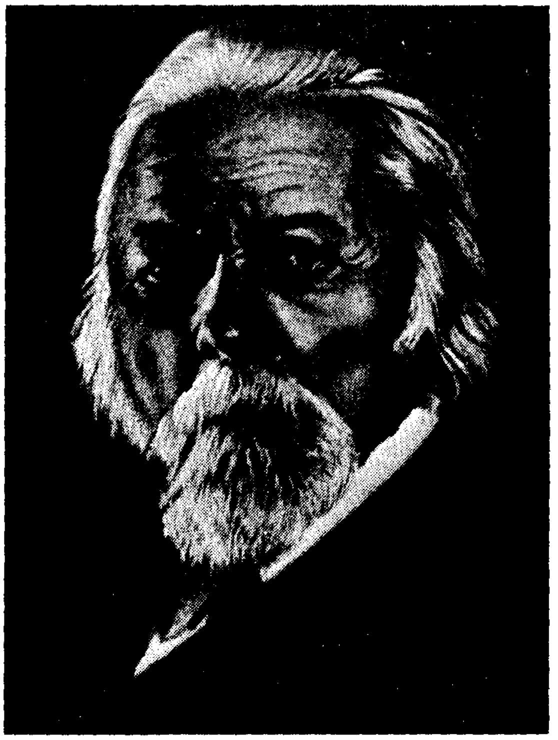
It is generally acknowledged that the journal "Uspekhi Fizicheskikh Nauk," which was founded in 1918, played a major role in familiarization of Soviet scientists with the achievements of foreign physics (and, of course, Soviet physics in equal measure).

Our attention is drawn to the fact that although the physicists of Petrograd, Moscow, and other cities became actively involved in all initiatives of the Soviet Government [it is sufficient to mention the studies of the Kursk Magnetic Anomaly that were done under the GOÉLRO (State Commission for the Electrification of Russia) plan], the first physics institutes set up in Soviet Russia were not administered by the Academy—simply because of the weakness of its prerevolutionary physics establishments. Only later, in the 1930's, were these institutes transferred to the Academy's jurisdiction, in testimony to the growth of its authority and influence. Another manifestation of this process was the transfer of the Academy from Leningrad to Moscow. At the end of 1933, the Central Executive Committee of the USSR (TsIK SSSR) placed the Academy of Sciences under the jurisdiction of the Council of People's Commissars "to establish a more perfect relation of the work of the USSR Academy of Sciences to practical socialist construction and to establish close and plan-oriented collaboration of the Academy of Sciences with the People's Commisariats and the State Planning Commission."

The removal of the Presidium of the Academy of Sciences and a number of its agencies to Moscow began in the middle of 1934.

The relevance of the Academy of Sciences to all aspects of the country's economic and social life increased with each passing year. A striking manifestation of this appeared during the difficult years of the Second World War—when the Academy of Sciences made its contribution to victory and the subsequent reconstruction and further growth of the national economy.

This role of the Academy of Sciences is reflected in the Resolution of the Central Committee of the Communist Party of the Soviet Union "On the 250th Anniversary of the USSR Academy of Sciences," which states that: "Following Lenin's directives aimed at strengthening the bonds between science and the national economy, Soviet scientists made a weighty contribution to the industrialization of the country, the socialist

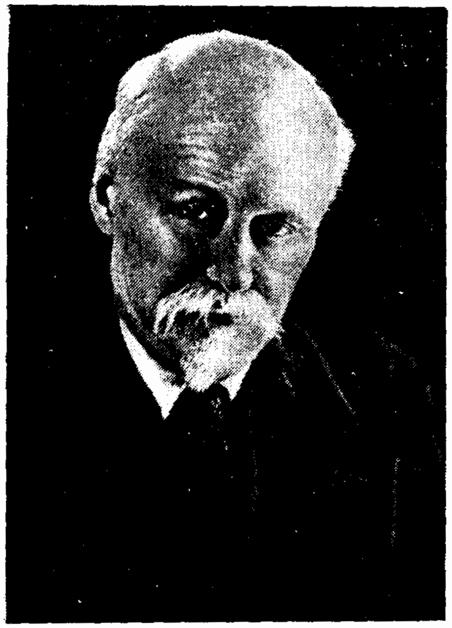


Academician A. P. Karpinskiĭ, President of the Academy of Sciences from 1917 through 1936.

transformation of agriculture, and fulfillment of the five-year plans. Discharging their patriotic duty to the Nation, scientists contributed selflessly to the victory of the Soviet People in the Great Patriotic War and to the reconstruction and subsequent growth of the national economy. The high level of research attained by Soviet scientists in many scientific areas created a base for successful solution of vital scientific and engineering problems."

The USSR Academy of Sciences as the country's organizing scientific center. During the Soviet period, the Academy of Sciences has come to function not only as a scientific-research establishment, but also as the country's organizing scientific center. Under its aegis and with its direct aid in the period from 1919 through 1961, Republic Academies of Sciences were created in all of the Republics of the Union as scientific cadre matured in those Republics. These Academies now have qualified cadre and numerous well-equipped institutes, which solve both general scientific problems and problems related to specific projects in the development of the national economies of the Republics. It is generally acknowledged that the research work done at the oldest Republic Academies (Ukrainian, Belorussian, Georgian, and others) is on a par with the world level, especially in the physical sciences. Even today, the USSR Academy of Sciences continues to assist the Republic Academies in many ways. There is a special Council in the Presidium of the USSR Academy of Sciences whose function is to coordinate the scientific activity of the Union Republic Academies of Sciences.

Assisting the Party and Government in the solution of vital projects in exploitation of the natural resources of specific large regions of the country and in development of their productive capacity, the USSR Academy of Sciences has created major scientific research centers



Academician V. L. Komarov, President of the USSR Academy of Sciences from 1936 through 1945.

Academician S. I. Vavilov, President of the USSR Academy of Sciences from 1945 through 1951.

Academician A. N. Nesmeyanov, President of the USSR Academy of Sciences from 1951 through 1961.

Academician M. V. Keldysh, President of the USSR Academy of Sciences since 1961.

in these regions. The largest of these centers is the Siberian Division of the USSR Academy of Sciences at Novosibirsk, which now numbers over thirty scientific research institutes (including several physics institutes) and a number of branches (East Siberian, Buryat, Yakutsk). The Urals and Far East Scientific Centers are among the largest. Branches of the Academy function in a number of the Autonomous Republics (Bashkirian, Daghestan, Kazan', Karelian, Komi) and on the Kola Peninsula.

The higher educational institutions are naturally of tremendous importance in the cultivation of science in the USSR. Contemporary Soviet physics would be unthinkable without our remarkable universities—notably those at Moscow and Leningrad. The stable and productive bonds between the USSR and Union Republic Academies of Sciences are well known. One of the most striking instances is found in the relationships that have developed between the Siberian Division of the Academy of Sciences and Novosibirsk University.

Democratic administration during the Soviet period. After the October Revolution, the Academy of Sciences was administered on a democratic basis. The office of President was held by scientists who had won recognition for their work in some field of science. The personal authority of the candidate as a scientist and social activist and his contribution to the development of a principal field of knowledge, in combination with outstanding ability as an organizer—these were the things that determined the choice of the Academicians.

The first elected president was Academician A. P. Karpinskiĭ (in office from 1917 to 1936), the founder of the Russian geological school, member of a number of foreign academies, and an important figure in the government (he was interred in the Kremlin). His successor was the Botanist V. L. Komarov, the foremost investigator of the Asiatic flora (1936—1945). The President elected in 1945 was S. I. Vavilov (1945—1951), a prominent specialist in optics and simultaneously a student of the works of Newton and Lomonosov and the organizer and first director of the FIAN. In retrospect, the Academy recognizes its debt to them.

For 10 years (1951—1961), the Academy of Sciences was headed by Academician A. N. Nesmeyanov, a prominent chemist and now Academician-Secretary of the Division of General and Technical Chemistry and Director of the Order of Lenin Institute of Organo-elemental Compounds of the USSR Academy of Sciences. Mstislav Vsevolodovich Keldysh, one of our most prominent mathematicians and mechanicians, was elected President in 1961. He occupies this prestigious and responsible post today.

The system set up to adminster to the country's center of scientific thought has produced positive results of its own.

Development of physics during the Soviet period. During the years following the revolution, a quantum jump occurred in the development of Soviet physics. It was manifested even during the first few years in the creation of scientific centers at which physical schools began to develop rapidly—a prerequisite to an indispensable element of continuity in science, the existence of which guarantees that it will progress and develop rapidly. In turn, the rapid development of qualified scientific cadre made it possible to organize the new physics institutes that were so acutely needed by the young country.

It is appropriate to recall here the physics schools that prepared qualified physics cadre and promoted the rapid development of the science during the first few years after the revolution.

The Lebedev physics school continued to exist and develop in the Moscow Institute of Physics and Biophysics, which was headed by Academician P. P. Lazarev. The naming of the Physics Institute (FIAN), which was formed after removal of the Academy of Sciences to Moscow from the Leningrad Physico-mathematical Institute that had been separated from it, after Lebedev was not only a tribute honoring the memory of a remarkable Russian physicist, but also reflected the fact that the research done in this new academic institute was to continue and develop the traditions of his remarkable school.

Two Leningrad schools are influential and generally recognized. One of them was developed by Academician A. F. Ioffe at the Physico-technical Institute, out of which several major physics institutes were eventually to grow. The Ioffe school was inseparably associated with the Polytechnic Institute, whose Department of Physics and Mechanics supplied the Leningrad Physics Institutes with qualified young cadre for many years. Many scientists who grew up in this school came to occupy positions of prominence in the Academy of Sciences.

A second Leningrad school was that of Academician D. S. Rozhdestvenskiĭ. He came out of Leningrad University and developed in the State Optical Institute, which was founded during the early years after the Revolution. This institute was deeply involved in the task of building the country its first optical industry.

The school of Academician L. I. Mandel'shtam, which developed at Moscow University and in the Academy of Sciences Physics Institute, was of prime importance for Soviet Physics. Out of it came more than a few scientists who were to work on problems in radiophysics, optics, and the theory of nonlinear oscillations. This school also produced a number of scientists who were elected Active and Corresponding Members of the Academy of Sciences.

We might, of course, mention other physical schools (for example, the school of Academicians L. D. Landau and I. E. Tamm and that of Academician N. N. Bogolybov were highly influential in theoretical physics; in nuclear physics, we might mention the school of Academician I. V. Kurchatov, and that of Academician S. I. Vavilov in optics). All of them appeared and developed when Soviet physics had reached its full maturity.

Basic achievements in the development of physics during the Soviet period. Observing the 50th anniversary of the Great October Socialist Revolution in 1967, this journal published (in its October number) a lengthy review by Prof. É. V. Shpol'skiĭ entitled "Fifty Years of Soviet Physics," and also reprinted more than thirty papers by the leading physicists of our country that represented pioneering studies and had become bibliographic rarities. Despite this wide exposure given to the attainments of Soviet physicists, the editors considered it necessary at the time to stress specifically that they were unable, in the space available, to present an exhaustive picture of the development of physics under the Soviets.

Presenting below a review of studies inseparably associated with the Academy of Sciences and carried out by its scientists during the postrevolutionary period, the editors are again obliged to caution that this presentation is inevitably condensed and incomplete.[8)]

a) Mechanical properties of solids. Chronologically, the first progress in Soviet physics is associated with the research of A. F. Ioffe in the physics of crystals. There is every justification for regarding these studies as continuing a tradition: crystallography and physical metallurgy had been represented in prerevolutionary Russia by P. P. Anosov, D. K. Chernov, E. S. Fedorov, and Yu. V. Vul'f.

The work of A. F. Ioffe and his closest collaborators —A. P. Aleksandrov, N. N. Davidenkov, S. N. Zhurkov, G. V. Kurdyumov, I. V. Obreimov, A. V. Stepanov and Ya. I. Frenkel'—laid the foundations for the modern physics of real crystals with their complex but directly practical problems of strength, structural imperfection, dislocations, and methods of investigation. As a result of these studies, it became quite feasible to make progress in the growing of ideal, perfect crystals whose strength and other physicomechanical properties approach their theoretical values.

Problems of producing perfect crystals are being worked on with success at the USSR Academy of Sciences Institute of Crystallography, where the pertinent research is associated primarily with the name of A. V. Shubnikov. L. F. Vereshchagin and his colleagues have recorded outstanding results in studies of the behavior of solids under ultrahigh pressure. For example, a method for the production of synthetic diamonds was developed and introduced to the industry as a result of these studies.

b) Optical research. Research in optics—applied and physical—has been developed with success from the very first days of Soviet power in our country. The earliest work is associated with the names of D. S. Rozhdestvenskiĭ, the organizer and first director of the State Optical Institute, I. V. Grebenshchikov, N. N. Kachalov, A. A. Lazarev, and their co-workers. As a result, the Soviet Union has an optical-glass industry that plays a highly significant role in science, engineering, and the country's defense. This makes obvious the importance of the resulting complete independence of many important industrial branches on deliveries from foreign firms.

Research in physical optics, including spectroscopic studies, is firmly associated with the names of D. S. Rozhdestvenskiĭ and A. N. Terenin and their schools. The research on fluorescence and phosphorescence that was directed by S. I. Vavilov has received wide recognition; more fundamental interest attaches to his work in the field to which he gave the name "the microstructure of light."

The spectroscopy of crystals was developed in the late 1920's in the papers of I. V. Obreimov. During the postwar years, the optical spectroscopy of semiconductors, which has now become a powerful tool for the investigation of their properties, made its appearance as a result of the investigations of E. F. Gross and his co-workers at Leningrad and A. F. Prikhot'ko and his colleagues at Kiev.

The work of L. I. Mandel'shtam and G. S. Landsberg on Raman scattering are a part of a treasury of physics. Mandel'shtam's influence on the emergence of research on the molecular scattering of light has been tremendous. The success of these studies was determined in many respects by this rare combination of the brilliantly gifted theoretician, experimentor, and radio engineer in a single individual.

Another generally acknowledged triumph of Soviet physical optics (one that relates genetically to the aforementioned works of Vavilov's school) has been the discovery, interpretation, and construction of a theory of the emission of faster-than-light electrons (S. I. Vavilov, P. A. Cerenkov, I. E. Tamm, and I. M. Frank). This work is also interesting in that it is an example of how a purely physical effect came into universal use in engineering (in Cerenkov counters).

c) Research in theoretical physics. Fundamental results obtained by Soviet theoreticians bear on the application of general quantum-mechanical relationships to various aspects of the electronic theory of solids, quantum fluids, and nuclear physics. Construction of the magnificent edifice that is quantum mechanics had been completed in the middle 1920's, and the small detachment of Soviet theoreticians arrived on the scene too late. Nevertheless, they obtained a number of results of general theoretical importance. Among these, we note first of all the work of L. M. Mandel'shtam and M. A. Leontovich on the indeterminacy relation for energy-time, which opened the way to explanation of a whole series of extremely important microphysical processes within the framework of tunnel-effect notions. Working independently of von Neumann, L. D. Landau introduced the notion of the density matrix (1927). The Tamm-Dancoff method for analysis of practical interactions, which went beyond perturbation theory, became widely celebrated in quantum mechanics.

A series of fundamental results in quantum-mechanical theory are due to V. A. Fock: a relativistic generalization of the Schrödinger equation (the Klein-Gordon-Fock equation), studies of secondary quantization, development of a general method for solution of the quantum-mechanical many-body problem (Hartree-Fock method).

The development of science often results in reappraisal, at each of its stages, of work done long previously—assuming that it has not been forgotten. Theoretical astrophysics and cosmology, which have developed so rapidly during the past 10—15 years as a result of progress in space technology and new possibilities and methods for observational astronomy, have produced such a reappraisal of the work of A. A. Fridman, who discovered the nonstationary Universe "at the tip of his pen"—a scientific feat that is all the more outstanding since it required a certain amount of scientific nerve from its author: Fridman's results contradicted those of Einstein.

The celebrated work of V. A. Fock (1939), in which he gave an approximate solution to the n-body problem within the framework of general relativity theory, was of fundamental importance. The Newtonian laws of motion of each of the bodies (material points) were derived here from the general equations of the gravitational field, with calculation of corrections to the Newtonian laws of motion and interaction.

d) Ultralow temperatures. It was observed long ago that, as a rule, the study of matter in its extreme states is of the greatest interest. It has been precisely in those extreme conditions—under ultrahigh pressures, at ultrahigh energies and ultralow temperatures—that we may expect the discovery of new effects, and the history of science has always justified these expectations (only the quantitative criteria, the points from which the "ultra" states are reckoned, have changed).

Penetration into the range of ultralow temperatures led Kammerling-Onnes to the discovery of superconductivity phenomena in 1911. In 1938, P. L. Kapitza discovered the superfluidity of He II. This discovery is rightly regarded as one of the most important accomplishments to come about in the Soviet Union.[9]

An exhaustive explanation of the superfluidity of helium was given soon thereafter by L. D. Landau, who developed the hydrodynamics of the quantum fluid and predicted a whole series of paradoxical effects on the basis of his theory—effects that were confirmed experimentally. They include the prediction that two sound-propagation velocities exist in helium; later, in the mid-1950's, Landau predicted—within the framework of Fermi-liquid theory—the existence of zero sound in He^3; this prediction has also been confirmed experimentally.

N. N. Bogolyubov made a major contribution to the development of superfluidity theory; with allowance for the interaction of Bose-gas particles, he obtained the energy spectrum of helium in the form that Landau introduced phenomenologically into his theory.

Important experiments in superfluidity were performed by V. P. Peshkov, É. L. Andronikashvili, B. G. Lazarev, and others. For example, Peshkov's experiments led to the discovery of the so-called second sound in He II, the existence of which had been predicted by Landau, while E. M. Lifshitz had performed the detailed calculations for the experiment.

Kapitza is credited with statement of the principles, development of the design, and construction of industrial installations for the production of liquid helium and liquid air: these exotic liquids were interesting not only in themselves, but have become a necessary tool in the modern physical experiment. These liquids have long since found applications in industry as well (liquid oxygen in metallurgy); even broader prospects for their use are opening now in connection with projected technical applications of superconductors.

Soviet theoreticians have turned in important work on superconductivity: a theory of superconductive alloys was developed by V. L. Ginzburg, L. D. Landau, A. A. Abrikosov, and L. P. Gor'kov (it is known abroad as the GLAG theory). The papers of N. N. Bogolyuov constitute a major contribution to superconductivity theory.

Superconductivity has been investigated experimentally by A. I. Shal'nikov, N. E. Aleksevskiĭ, Yu. V. Sharvin, and others.

e) Electrical properties of solids; semiconductors and magnetism. Beginning in the late 1920's and early 1930's, first in Leningrad and then at other scientific centers of the country, research on a new class of substances, the semiconductors, developed vigorously. The initiator of these studies was A. F. Ioffe. However, he must be credited not only with stimulating them, but also for a whole list of important results. The latter pertain to photoelectric phenomena (the negative photoeffect, which was observed and explained in a study by A. V. and A. F. Ioffe) and to the physics of rectification and the metal-semiconductor boundary. A diffusion theory of the photoeffect as applied to cuprous-oxide rectifiers was developed successfully before the war by B. I. Davydov and D. I. Blokhintsev (the latter also authored important investigations in the theory of the photoelectric effect).

I. E. Tamm's famous study of surface levels dates from the early 1930's; the Nobel lectures of the American physicists who invented the transistor begin with an exposition of its results.

Conceptions as to the influence of the tunnel effect on the conductivity of semiconductors were developed in the papers of L. V. Keldysh (consideration of the role of phonons in interband transitions and the "resonant" nature of this effect). Keldysh also predicted features of the absorption of light in strong fields near the edge of an absorption band (Franz-Keldysh effect).

The physics of quasiparticles forms a thick chapter in the electronic theory of solids. Soviet scientists made a definite contribution to this rapidly developing scientific area. The first quasiparticle, the phonon, was introduced into the theory by Tamm in his paper on Raman scattering. It was in this 1929 study that Tamm quantized the "thermal field" and introduced the notion of "elastic quanta" (in Wilson's terminology, sound quanta). A very broad range of the thermal and electrical properties of solids are now studied and discussed in "phonon language."

The next quasiparticle was the exciton, which Frenkel' introduced in (1931) to describe the phenomena of "currentless" absorption of light. Exciton theory was developed successfully in the papers of A. S. Davydov, V. L. Ginzburg, and S. I. Pekar.

We take note here of the extremely important investigations of excitons that were carried out by E. F. Gross and his co-workers beginning in 1951 (when the first hydrogen-like exciton spectrum was recorded in cuprous oxide).

In the years that followed, the theory of quasiparticles was advanced successfully by I. M. Lifshitz and a large group of his students and colleagues. This school did fundamental research on the energy spectrum of conduction electrons and developed general methods for determining the shape of the Fermi surface from data on the various electronic states of metals.

Large staffs headed by V. M. Tuchkevich developed the first Soviet germanium and silicon transistors and did the research leading to creation of the high-capacity rectifiers and converters known as thyristors, while those under N. G. Basov and B. M. Vul worked on the development of semiconductor lasers.

From the early 1950's, thermoelectric phenomena have been studied intensively and successfully, one main purpose being the development of efficient thermal converters. This effort was also joined by A. F. Ioffe during the last few years of his life.

Soviet physicists have made a major contribution to the theory of magnetism. Here we should take note of the papers of Frenkel' on the quantum-mechanical theory of ferromagnetism and explanation of the domain structure of ferromagnets (Yu. I. Frenkel' and Yu. G. Dorfman; N. I. Akulov; L. D. Landau and E. M. Lifshitz). Landau's paper on the diamagnetism of free electrons is justly ranked as a classic. Soviet physicists predicted the phenomena of antiferromagnetism (Landau) and piezomagnetism (A. S. Borovik-Romanov).

E. K. Zavoyskiĭ's discovery of electron paramagnetic resonance was a most important achievement. S. V. Vonsovskiy and the Sverdlovsk physicists contributed significantly to development of the theory of magnetic phenomena and equally to their use for purposes of industrial flaw detection.

f) Nuclear and high-energy physics. The position that nuclear physics has come to occupy in science and in all of our lives is generally known. Pierre Curie only guessed dimly at its future role; Rutherford and, to an even greater degree, Einstein long regarded it as insignificant from the standpoint of applications.

Research in nuclear physics began in the Soviet Union during the first half of the 1930's and the early progress is associated with theoretical studies: the proton-neutron model of the nucleus (D. D. Ivanenko), exchange forces and their role in the nucleus (I. E. Tamm and D. D. Ivanenko), the liquid-drop model and the Bohr-Frenkel' electrocapillary theory of fission, the theory of the chain fission reaction in uranium enriched with its light isotope (Ya. B. Zel'dovich and Yu. B. Khariton). Application of the concepts of superfluidity (N. N. Bogolyubov) and quasiparticle conceptions (A. B. Migdal) to description of nuclei resulted in significant results in nuclear physics after the war.

L. V. Mysovskiĭ, I. V. Kurchatov and their co-workers performed important research in the mid-1930's on the isomerism of atomic nuclei; in Kurchatov's laboratory at the Physicotechnical Institute, his junior colleagues G. N. Flerov and K. A. Petrzhak discovered the spontaneous fission of uranium (1940). After the war, Flerov and his co-workers recorded fundamental results and discoveries associated with the synthesis of transuranium elements, using a heavy-ion accelerator.

Kurchatov and the enormous staff of scientists and engineers that he directed deserve our country's gratitude for their solution of the uranium problem, the development of the new weaponry, and the promotion of nuclear power engineering. The names of Kurchatov's closest colleagues and collaborators—A. P. Aleksandrov, A. I. Alikhanov, Ya. B. Zel'dovich, I. K. Kikoin, A. I. Leĭpunskiĭ, Yu. B. Khariton and many, many others are inseparably associated with this entire complex of projects in its unprecedented scale. Kurchatov most also be credited with the initiative that started our thermonuclear-fusion research—an engineering problem of incomparable importance, solution of which will guarantee humanity inexhaustible energy sources once and for all. These studies have been and are being pursued by a large team that has worked for many years under the inspired leadership of L. A. Artsimovich (we give first mention to M. A. Leontovich, G. I. Budker, E. K. Zavoĭskiĭ, B. B. Kadomtsev, R. Z. Sagdeev, and others). K. D. Sinel'nikov at Khar'kov and B. P. Konstantinov at Leningrad have also contributed significantly to the aggregate of these studies.

Progress in nuclear physics would be unthinkable without progress in the physics and technology of accelerators, which in our country is associated principally with the many-sided activity of V. I. Veksler. The phase stability principle that he proposed has been built into giant modern accelerators. The major advances made in research on colliding-beam accelerators with storage rings are associated with the work of G. I. Budker and his co-workers of the Siberian Division of the Academy of Sciences.

The development of Soviet "accelerator building" has been due in many respects to A. I. Alikhanov, V. V. Vladimirskiĭ, V. P. Dzhelepov, A. A. Logunov, M. G. Meshcheryakov, and A. L. Mints.

Research in cosmic-ray physics (which began somewhat earlier) is closely related to nuclear-physics research. D. V. Skobel'tsyn is an acknowledged pioneer in these studies. Research in this direction is being developed by S. N. Vernov.

Research in the fields of high-energy physics and elementary particles is being pressed on a broad front in the USSR. These studies are being conducted on a large scale.

The most monumental results here have been obtained by L. D. Landau (the idea of combined parity), I. Ya. Pomeranchuk (Pomeranchuk's theorem of equality of the proton-proton and proton-antiproton cross sections at high energies), M. A. Markov and B. M. Pontecorvo (neutrino physics), and V. N. Gribov (research in the theory of complex angular momenta).

Important experiments that led to confirmation of the existence of weak nucleon-nucleon-interaction were performed by Yu. G. Abov and V. M. Lobashov. These studies are being pursued in the Institute of Theoretical and Experimental Physics, at Serpukhov, Dubna, the FIAN, the Leningrad Nuclear Physics Institute, and in many other scientific agencies of our country. We should note the remarkable results of the Serpukhov experiments in which the helium "antinucleus" was first produced.

g) Space technology. We are witnesses to continuing differentiation and specialization in physics, chemistry, and the other sciences. In this process, "border" areas very quickly become fully independent divisions of our natural sciences. There are now practically no universal physicists who would range over the entire breadth of physics in their work.

At the same time, there are more than a few examples in which the final products palpably and perceptibly embody progress made, it would appear, in unrelated branches of science—as though the trait of universality had gone over from the men to the products of their thoughts and labors.

This applies most fully to the products of space technology. Its successes, which have aroused universal excitement, are associated in our country with the work of a prominent scientist, Academician S. P. Korolev—a man with many similarities to Kurchatov.

Specialists in mechanics, physical gasdynamics, computer technology, and radioelectronics—the entire gigantic complex covered by the blanket term "space technology"—have made their contributions to progress in the exploration of space. The launchings of the first artificial earth satellites (1957), which were soon followed by orbiting of the Vostok-1 spacecraft with Yuriĭ Gagarin aboard, marked the beginning of a whole era that will always be associated with Soviet science and engineering. The USSR Academy of Sciences and its scientists—M. V. Keldysh, A. A. Blagonravov, G. I. Petrov, L. I. Sedov, and others—contributed greatly to these projects.

h) Radiophysics and quantum electronics. Research in radiophysics and the theory of oscillations has become a part of the "gold reserves" of Soviet science. Despite the fact that wireless telegraphy was discovered in our country and its role in cultural life and the possibilities for extensive technical applications were immediately evident both to the inventor of radio himself, A. S. Popov, and to his prominent compatriots, it was only during the Soviet years that intensive development of radioengineering and the fundamentals of radiophysics and oscillation theory begun. The foundations for all of these studies were laid by the investigations of a large collective of engineers and physicists who worked at the Nizhniĭ Novgorod Radio Laboratory (in whose organization Lenin played such a large part) under the supervision of M. A. Bonch-Bruevich, V. P. Vologdin, A. F. Shorin, and others, and in the work of M. V. Shuleĭkin at Moscow and L. I. Mandel'shtam and N. D. Papaleksi at Odessa (their work was later continued in Moscow). At Leningrad, radiophysical research was conducted by A. A. Chernyshev, D. A. Rozhanskiĭ, and others during the early years of Soviet power.

Among all of these investigations, we take note first of all of the work on the theory of nonlinear oscillations, which was inseparably linked to the names of L. I. Mandel'shtam, N. D. Papaleksi and their immediate co-workers (A. A. Andronov, M. A. Leontovich, A. A. Vitt, S. M. Rytov, S. É. Khaĭkin, and others).[10]

The advance into higher and higher frequency ranges that has been characteristic in all stages of the development of radio implied the need to find qualitatively new principles of amplification and generation of the radio-frequency vibrations. The idea of using electron-velocity modulation for these purposes was due to D. A. Rozhanskiĭ, and the first practical steps toward its realization were taken by representatives of A. A. Chernyshev's electrophysical school (his colleagues at the Leningrad Electrophysical Institute, which had been separated from the Physico-technical Institute)—N. D. Devyatkov, N. S. Alekseev, D. E. Malyarov, and others, and of the Bonch-Bruevich School. G. A. Grinberg made a major contribution to the theory and design of devices for the microwave band.

Research on radio-wave propagation is the most vital component in the whole complex of radioengineering and radiophysical problems. Here we should note the ideas of Mandel'shtam and Papaleksi on the interference of radio waves, with its applications in the measurement of propagation velocities and distances.

For detection of moving targets, Leningrad physicists headed by D. A. Rozhanskiĭ and Yu. B. Kobzarev had, even before the war, elaborated the principles of radar and built units that were successfully tested in 1938. By the beginning of the Second World War, the arsenal of the Red Army included several radars with ranges up to 150 km. Several of these devices were in operation on the Leningrad front.

The idea of using radio in astronomy, and especially that of receiving radar echoes from the moon, was advanced by Mandel'shtam and Papaleksi. The studies of V. L. Ginzburg, I. S. Shklovskiĭ, and others contributed greatly to the development of theoretical radio astronomy; V. A. Kotel'nikov and his group of co-workers are to be credited with important results in radar beaming of the planets.

A "nonlinear psychology" (to use S. É. Khaĭkin's apt expression), has begun to permeate accoustics (N. N. Andreev, B. P. Konstantinov). During the past few years, we have witnessed progress in nonlinear optics, a field whose investigation was developed by R. V. Khokhlov.

The high discipline with which radiophysical research was imbued at the FIAN under its remarkable organizers was also responsible in many respects for the fact that it was at this institute, the largest one in the country, that basic research in quantum electronics was begun in 1951 at the initiative of A. M. Prokhorov. As early as 1952, Prokhorov and N. G. Basov had advanced the idea of a quantum generator whose operating principle would be based on stimulated emission (the theoretical conceptions go back to a 1916 paper of Einstein). Since that time, the FIAN has rightly been regarded as our country's center of quantum electronic research. The first molecular generators (masers) were built there in 1954 and, in the same year, by C. Townes in the USA, who was working independently of Basov and Prokhorov). The functioning of molecular generators involves problems of creating inverted level populations. A method for obtaining inverted populations, the famous three-level system with optical pumping, was proposed by Basov and Prokhorov.

Following the invention of the masers, the development of quantum generators operating in the optical wavelength band has been the most important achievement in quantum electronics. Optical quantum generators (lasers) can definitely be characterized as the most interesting and promising of quantum-electronic devices. It is significant that it has been possible to obtain lasing effects in an extremely broad class of substances. Crystals (such as ruby), gases, and semiconductors are all used as active materials for lasers. The first semiconductor laser used gallium arsenide. Scientists at the country's two senior institutes—the FIAN and the Physico-technical Institute—had a part in its development.

The range of applications of quantum-electronic devices is expanding with each passing year and at a steadily increasing rate. Their influence on the development of physics as a whole is also growing. In astronomy and astrophysics, radar sounding of the planets, measurements of the astronomical constant, and study of interstellar matter became possible only with the use of low-noise parametric amplifiers as receivers of the faint reflected signals. In plasma physics, we have laser diagnostics and the creation of high-temperature plasma with the laser beam. The advances in nonlinear optics of which we spoke about have been possible in large part because of the enormous concentrations of energy and the gigantic field strengths that can be obtained with lasers. Holography would be unthinkable now without lasers; they are already in use in radar, space-communications, computer, and medical applications.

Soviet physicists can take pride in the fact that the foundations for this entire complex of physical and technical work were laid by research done in our country.

Little more than half a century has passed since science was placed at the service of the people in the Soviet Union. This is a very short time on the historical scale. But how colossal has been its development! In physics alone, dozens of specialized institutes of the first magnitude have come into being and are functioning productively. Hundreds of thousands of highly qualified scientists are working successfully on the solutions of problems of contemporary science. Socialism has given them unlimited opportunity for scientific exploration. They work with the knowledge that the scientific results of their creation will be used only for high humanitarian purposes, and not in the egotistical interests of private concerns and military-industrial complexes. In the example of their foreign colleagues, such as Einstein, Born, and others, Soviet physicists could see clearly the oppressive consequences of the fact—a characteristic one for capitalist society—that the achievements of nuclear physics were used in their time in the interests of imperialist policy. The democratic orientation of Soviet scientists, who are of one mind and one body with their people, is in tune with the interests of all the people, and this is their great good fortune and a powerful stimulus to creativity.

It is this unity of purpose of our men of science and the nation as a whole, the conscientious collaboration of the Party and Government with science, that elevated and organized Soviet science so quickly to a level of achievement on a par with the world level, with a record of pioneering in many areas.

But while we point with pride to the achievements of Soviet science at this anniversary, we must note at the same time that the demands made of it have also become incredibly more exacting.

These demands stem from the fact that the scientific-technical revolution has, at the present point in history, become a most important arena in the competition between the two opposed world systems, Socialism and Capitalism. As Comrade Brezhnev noted in his message to the Twenty-Fourth Party Congress, science and its discoveries have started an upheaval in the development of productive forces whose importance and profoundity will continue to increase steadily. Hence arises "a problem of historical importance: that of organically combining the achievements of the scientific-technical revolution with the advantages of the socialist economic system, of developing more broadly the forms of the union between science and production that are inherent to socialism."

The Party tells us that we may no longer content ourselves with specific achievements during this new stage, no matter how great they may be: it is necessary to attain a new level of organization in science, to focus its efforts sharply on the development of productive forces, and to put its results into practice in the national economy without delay. This should not be interpreted as making science a production foreman whose function is to clearup everyday bottlenecks. Science will perform its mission fully only when it exhibits its power to transform the entire technology of material production; bold new advances are needed in large-scale scientific problems, farsightedness in the organization of fundamental research that changes the relation of man to nature radically and in reasonable fashion.

Such research requires enormous concentrations of money and trained personnel, and this places a great responsibility on the directors of scientific staffs and on the scientific community: their identification of worthwhile scientific objectives and paths leading to them must be as accurate as sniper fire. Soviet science has reached a high level, and such are the problems with which it must deal.

The resolution of the Central Committee of the Communist Party of the Soviet Union noting the Two Hundred-Fiftieth Anniversary of the Academy states with confidence that "in marking this occasion, the country's scientists and the staff of its scientific research establishments will bend their efforts to meeting the objectives set forth by the Twenty-Fourth Party Congress, achieve new successes in the further development of leading scientific trends and in the introduction of scientific achievements into material production, thereby making a worthy contribution to the general struggle for communism."

There is no doubt that the USSR Academy of Sciences and its many thousands of workers, like all scientists of the nation of the Soviets, will justify the high confidence that the party and the people have placed in them.

LITERATURE ON THE HISTORY OF THE USSR ACADEMY OF SCIENCES AND ON PHYSICAL RESEARCH

1) True, Newton interested Peter I primarily as director of the Royal Mint, and not as a scientist: it is known that the silver money in circulation was recoined by decree of Peter.

2) L. L. Blumentrost was named President a year later.

3) There is a somewhat different version, also traced to Tatishchev. In the same conversation, he is said to have told Blumentrost: "You seek seed in vain when the ground is unprepared for sowing," and Peter responded in about the same vein, with a metaphor. Both versions should be taken with a grain of salt: in his history of Peter, Pushkin writes, though on another subject: "... That which Tatishchev reports can rarely be believed."

4) In the French Academy of that time, foreign corresponding members were even assigned to specific active members, through whom the Academy was advised of their work and the work of their colleagues and compatriots.

5) The "Commentaries" of the St. Petersburg Imperial Academy of Sciences were printed in Latin from 1728 through 1751 and included papers in mathematical, physical, and historical classes. They were reprinted at Bologna even during the years of their publication (1740).

6) It is much less well known that a similar fate befell Daniel Bernoulli. His works in hydrodynamics were "rediscovered" in 1859, and only then did his "Hydrodynamics" come into the hands of a broad circle of scientists (this work had been published earlier, in 1738, again in Latin). A whole series of propositions of the kinetic theory of gases that were "rediscovered" during the first half of the Ninenteenth Century were set forth in the "Hydrodynamics".

7) A similar picture prevailed in other fields of knowledge: such standard-bearers of Russian Science as K. A. Timiryazev, D. I. Mendeleev, and I. M. Sechenov were only Corresponding Members, and N. I. Lobachevskiĭ worked entirely outside of the Academy.

8) At the end of the article (p. 303), we present a brief list of books illuminating the history of the Academy of Sciences and the history of its most recent physical researches.

9) In the mid-1920's, P. L. Kapitza also produced ultrastrong magnetic fields, in which he observed unusual electrical conductivity properties in a number of metals.

10) N. M. Krylov and N. N. Bogolyubov developed a theory of nonlinear oscillations at Kiev, but they did not concentrate their attention on its radioengineering applications.

11) More than thirty fundamental and bibliographically rare papers of our country's leading physicists that were written during the years of Soviet power were reprinted in the anniversary numbers of this journal (for October and November 1967). The 1967 anniversary issues of practically all of the academic physical journals also published specialized reviews, each in accordance with the profile of the journal.

12) This and the books listed below are being prepared for release by Nauka Press.

[1] P. P. Lazarev, Ocherki istorii russkoĭ nauki (An Outline History of Russian Science), Izd-vo AN SSSR, Moscow-Leningrad, 1950.

[2] Materialy k istorii Akademii nauk SSSR za sovetskie gody (1917–1947) (Sources for a History of the USSR Academy of Sciences During the Soviet Years (1917–1947)), Izd-vo AN SSSR, Moscow-Leningrad, 1950.

[3] V. P. Zubov, Istoriografiya estestvennykh nauk v Rossii (XVIII v.–pervaya polovina XIX v.) (Historiography of the Natural Sciences in Russia (Eighteenth Century and First Half of Nineteenth Century)), Izd-vo AN SSSR, Moscow, 1956.

[4] Istoriya Akademii nauk SSSR. (A History of the USSR Academy of Sciences). In 3 Volumes: Vol. 1, Izd-vo AN SSSR, Moscow-Leningrad, 1958; Vol. 2, Nauka, Moscow, 1964.

[5] M. I. Radovskiĭ, M. V. Lomonosov i Peterburgskaya Akademiya nauk (M. V. Lomonosov and the Petersburg Academy of Sciences), Izd-vo AN SSSR, Moscow-Leningrad, 1961.

[6] B. V. Levshin, Akademiya nauk SSSR v gody Velikoĭ Otechestvennoĭ voĭny (1941–1945) (The USSR Academy of Sciences During the Second World War (1941–1945)), Nauka, Moscow, 1966.

[7] Oktyabr' i nauchnyĭ progress (The October Revolution and Scientific Progress), Books 1-2, Izd-vo APN, Moscow, 1967.

[8]Sibirskoe otdelenie Akademii nauk SSSR (The Siberian Division of the USSR Academy of Sciences), Nauka, Siberian Division, Novosibirsk, 1967.
[9]Razvitie fiziki v SSSR (The Development of Physics in the USSR), Books 1-2, Nauka, Moscow, 1967.
[10]É. V. Shpol'skiĭ, Fifty Years of Soviet Physics, Usp. Fiz. Nauk 93, 197 (1967) [Sov. Phys.-Usp. 10, 678 (1968)];[11] Ocherki istorii razvitiya sovetskoĭ fiziki (1917–1967) (An Outline History of the Development of Soviet Physics (1917–1967)), Nauka, Moscow, 1969.
[11]Akademiya nauk SSSR. Kratkiĭ ocherk istorii i deyatel'nosti (The USSR Academy of Sciences. A Brief Sketch of Its History and Activity), Nauka, Moscow, 1968.
[12]G. D. Komkov, O. M. Karpenko, B. V. Levshin, and L. K. Semenov, Akademiya nauk SSSR—shtab sovetskoy nauki (The USSR Academy of Sciences: the General Staff of Soviet Science), Nauka, Moscow, 1968.
[13]Lenin i Akademiya nauk. Sbornik dokumentov (Lenin and the Academy of Sciences. Collected Documents), Nauka, Moscow, 1969.
[14]A. V. Kol'tsov, Lenin i stanovlenie Akademii nauk kak tsentra sovetskoi nauki (Lenin and the Development of the Academy of Sciences as the Center of Soviet Science), Nauka, Leningrad, 1969.
[15]Lenin i sovremennaya nauka (Lenin and Modern Science), Books 1-2, Nauka, Moscow, 1970.
[16]Ustav Akademii nauk SSSR (The Charter of the USSR Academy of Sciences), Moscow, 1970.
[17]Akademii nauk—250 let (The Academy of Sciences: 250 years), Nauka[12], Moscow.
[18]G. D. Komkov, B. V. Levshin and L. K. Semenov, Akademiya nauk SSSR. Kratkiĭ istoricheskiĭ ocherk (The USSR Academy of Sciences. A Brief Historical Sketch), Nauka, Moscow.
[19]Chleny Akademii nauk SSSR. 1724–1974 (Members of the USSR Academy of Sciences, 1724–1974), Nauka, Moscow.
[20]Ustavy Akademii nauk (Charter of the Academy of Sciences), Nauka, Moscow.

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