THE PROPHET IN HIS HOMELAND

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ABSTRACT

The author suggests an essay on the biography of Russian academician Vasily Petrov. For more than half a century, some preferred not to be reminiscent of the name of the discoverer of the electric arc, others thought it shameful to to eulogize an academician-commoner, who had not even recognized the priority of foreign scientists in Russian science. Only a happy occasion gave impetus to restoration of historical justice – and today Vasily Petrov is revered as the founder of domestic electrical engineering.

Keywords: electrical engineering, Vasily Petrov, electric arc, battery, galvanic-voltaic experiments, luminescence, history.

Background. *Academician of the Russian Imperial Academy of Sciences Vasily Petrov was among the pioneers of Russian domestic electrical engineering, still his life and works are not widely known to the reading public.*

Objective. *The objective of the author is to consider biography of Vasily Vladimirovich Petrov.*

Methods. *The author uses general scientific methods and historical-retrospective analysis.*

Results.

The first Russian electrical engineer, Academician of the Russian Imperial Academy of Sciences, Professor of St. Petersburg Medical and Surgical Academy (now Military Medical Academy) Vasily Vladimirovich Petrov was born on July 19 (8 old style) 1761 in Oboyan of Belgorod province (since 1796 – in Kursk province) in the family of a parish priest.

He was taught to read and calculate by his father at home. He received his primary education in a parochial school, then was appointed to Kharkov Collegium, where natural, humanities and foreign languages were taught.

Precise mechanics built devices

In 1785, to continue his studies, he moved to St. Petersburg, because of a lack of sufficient funds, he entered at the state expense the Teacher's Seminary (later converted to an institute), which trained primary school teachers. Simultaneously with training Petrov begins to teach mathematics and physics in the capital city. In 1788, the Commission for Public Education sent him to the Altai to Barnaul. There he conducted classes in physics, mathematics, Russian and Latin languages at the Mining College at the largest Kolyvan-Voskresensk mining plants.

After termination of the stipulated term of work Vasily Vladimirovich returned to St. Petersburg in 1791. From 1791 to 1797 he taught mathematics and Russian at the Engineering Cadet School at Izmaylovsky Regiment and since 1793 – physics and mathematics at the Main Medical School at the Military Land Hospital. In 1795, when this college was transformed into the Medical and Surgical Academy, he received the title of extraordinary (supernumerary) professor of mathematics and physics after a brilliant «est lecture». In 1802–1827 he taught physics and mathematics at the Imperial Academy of Arts and was a professor of physics at the Second Cadet Corps in St. Petersburg, where officers were trained for artillery and engineering units of the Russian army.

Petrov taught physics according to his own written guidance, accompanying his lectures with specially set experiments and demonstrations. Experiments for obtaining of electricity were especially well prepared. Under the editorship of the Russian professor in 1807, the translation of Schrader's textbook «The Initial Foundations of Physics for Use in Gymnasiums» was published. In it, he reworked and supplemented the chapter on electricity. This textbook, widely used in Russia, was used until the early 1930s.

Having received in 1799 at the Medical and Surgical Academy the chair of mathematics and physics, which he occupied for 34 years, Petrov created physics cabinet (laboratory), the first in Russia and one of the best in the world, for educational demonstrations and scientific research. The cabinet was continuously replenished by purchasing equipment and devices from individual scientists and ordering abroad. In addition, he himself, as well as St. Petersburg glassworks and precision mechanics, following his assignments and sketches, manufactured physical equipment.

By the end of the scientist's career, the exemplary physical cabinet was located in several rooms and 631 devices were on the list (not including small devices, parts and tools), of which about 250 belonged to experiments on electricity and magnetism. He achieved the inclusion in the teaching of physics of laboratory works (practical work) and insisted that teachers with students continuously conduct scientific experiments in the physical cabinet. Petrov contributed to the arrangement of such cabinets in other higher educational institutions: some instruments were handed over to Vilnius University and Moscow Department of the Medico-Surgical Academy.

His first scientific work was «Collection of physicochemical new experiments and observations by Vasily Petrov, professor of physics at the Academy of St. Petersburg Medical-Surgical and Free Arts. Part one, in St. Petersburg, in the printing house of the State Medical College, in 1801» and it concerned the theory of combustion. In the 17th–18th centuries, on the proposal of the supporters of the phlogiston theory, the substances during burning and roasting allegedly lose their constituent part «beginning of combustion». He experimented with the validity of the oxygen theory of combustion of the French chemist A. L. Lavoisier: combustion of solid and liquid substances occurs only in the presence of oxygen or air entering into them, if combustion takes place in an «airless place» (in thin air).

Simultaneously, Petrov described his experiments on determining the limiting temperature at which phosphorus ceases to glow or slowly burn in pure atmospheric air. He proved that the cause of fluorescent emission (fluorite mineral, fluoride subclass) is different from that of phosphorus, outlined the reasons for ignition of potassium in contact with water, oxidation of metals, etc.

For this scholarly work Vasily Petrov in 1802 was awarded the title of ordinary (full-time) professor,

and in 1808 – Academician of the Medical-Surgical Academy. Such a flattering and binding title was attributed to him by a government decree.

Electrical shock is deadly

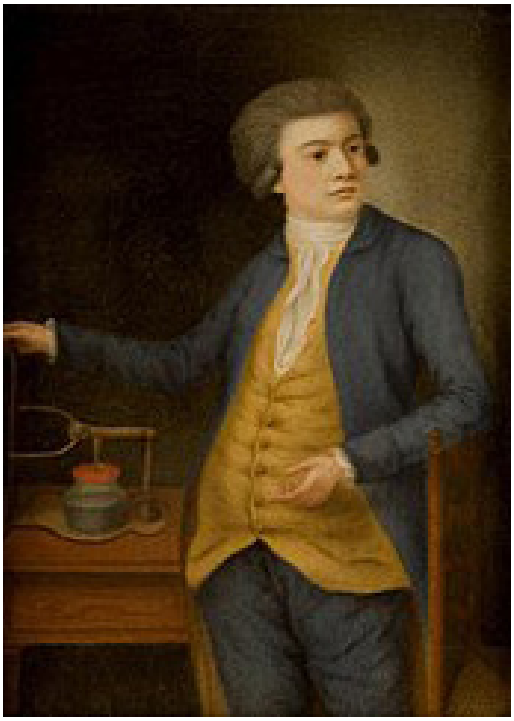
Almost until the end of the 18th century, scientists from different countries were engaged in studying the phenomena of static electricity. In 1791, the Italian anatomist and physiologist L. Galvani published the results of a research of the electrical phenomenon in muscle contraction («animal electricity»). Slight intensity and weak effects compared to static electricity were the reason that the interest around the scientist's explanations was supported not by development of experiments and accumulation of data, but by the polemics between supporters of his ideas (mainly doctors and biologists) and opponents (mostly physicists). The craving for galvanism was explained by creation in 1800 by the Italian physicist and physiologist A. Volta of the first chemical source of electromotive force (electric generator), through which the actions described by Galvani could be significantly strengthened and a continuous manifestation of the cause of these actions (electric current) in conductors during a long time could be provided.

Petrov first conducted experiments on a vertical voltaic column of 100 zinc and 100 copper circles with a diameter of 10 inches (0,254 m), acquired in Europe. Then he came to the conclusion that the most complete and comprehensive study of galvanic phenomena is possible in the presence of a more powerful source of electrical energy. According to his design, the instrumental mechanic of the academic chamber, the Englishman J. Mejer, by April 1802, created a huge battery of 4200 copper and zinc circles with a diameter of 1,4 inches (35 mm) and a thickness of about one tenth of an inch (2,5 mm). Between each pair of metal plates cardboard circles were laid, moistened with a solution of ammonia.

A battery of 2100 copper-zinc elements connected in series was horizontally arranged in four rows in a rectangular mahogany box 10 feet long (3,048 m). The total length of the galvanic battery was about 12,2 m. At that time it was the world's largest source of electrical energy. With a horizontal structure, the gravity of the upper layers of the plates did not squeeze out the liquid from the lower cardboard pads. This led to weakening of the first battery of 100 elements and prevented creation of large-sized current sources. The bottom, the walls of the box and the dividing partitions were covered with a thick layer of wax lacquer and oiled paper. The sections of the battery were connected together by a wire conductor, insulated with a sealing wax. In the presence of insulation, the battery showed a much stronger effect under the same other conditions.

There were no measuring instruments yet. Petrov used his own finger with cut skin as an indicator of the strength of the battery. He brought the bare ends of wires of different polarity to the wound. The more painful and unpleasant was the touch, the more powerful was the battery, in his opinion. According to modern data [5], the electromotive force of the battery was 2000–1650 V, the short-circuit current is 0,2–0,1 A, and the maximum useful power is 85–60 W. When the scientist tried to «measure» the power of the battery, he received an electric shock and lost consciousness. He remained alive due to the large internal resistance of the source of electrical energy.

Thus, in 1802, he found out the deadly danger of electric shock to a person, as he reported in his work «The news of galvanic voltaic experiments, which was



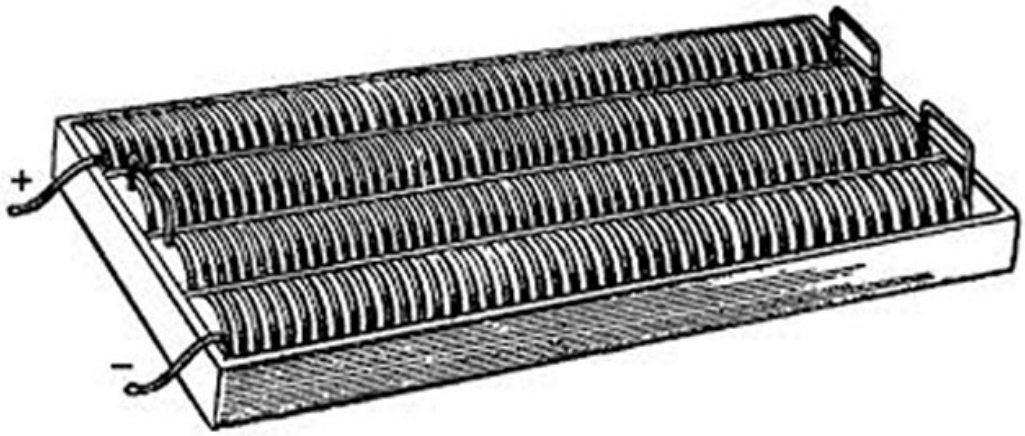
made by the professor of physics Vasily Petrov, by means of a huge, especially battery, sometimes consisting of 4200 copper and zinc circles and located at St. Petersburg Medical-Surgical Academy. In St. Petersburg, in the printing house of the State Medical College, 1803». This publication was republished in 1936 [8] and 1956 [9].

In the first book on electrical engineering, published in Russian at the state expense, the scientist described in detail the methods of making a galvanic battery, caring for it, the method of experiments, the results of his various experiments and gave recommendations on practical application of electricity. A separate chapter of the book is devoted to the effect of current on the human and animal organism and recommendations for doctors are given. The electrophysical laboratory created by him allowed from the middle of 19th century the professors of the Military Medical Academy, N. G. Egorov, V. V. Lebedinsky, A. V. Lebedinsky, N. P. Khlopin, S. A. Lebedev, to launch serious research in the field of the use of electricity for treatment of sick people [2].

«**The Kursk arc**»

A powerful source of current helped Petrov for a short time to conduct a lot of research, which opened a variety of ways to use electricity. He made the first public experiments on May 29 (17 old style) 1802 in the presence of the Medical Board (in modern terminology – the ministry) and many famous people.

The battery was so powerful that when the circuit broke it sparked. In case of placement of charcoal (well conducting current) at a place of rupture at a distance of one to three lines (2,54–7,62 mm), an electric current produced a flame. He studied the properties of this luminescence and discovered the possibility of using it for illumination, and high temperature that arises in a voltaic arc with metal electrodes for melting, welding and reducing metals from their oxides. The scientist received lead, tin and mercury in pure form from the charge with their



Galvanic battery of Petrov's design. The box was made of mahogany and its length was about three meters.

oxides and powder of charcoal, fat and squeezed oils (with carbon, but in peculiar forms and compounds).

The electric arc of Petrov was later applied to the case by domestic scientists: P. L. Schilling – when creating an electrical fuse to ignite underwater mines [10]; P. N. Yablochkov and V. N. Chikolev – for lighting [11–12]; N. N. Benardos and N. G. Slavyanov – for welding and cutting metals [13, 14]. In 19th century, arc generators of undamped electromagnetic oscillations found their place in electrical communications, with the help of which radio stations received electromagnetic waves with a frequency of up to several hundred kilohertz. Nowadays this discovery is used in arc sources of light (powerful searchlights), electric welding, electrometallurgy, where electric arc furnaces with productivity from fractions to hundreds of tons serve for smelting cast iron, high grades of steel, alloys and other metals. They are also used in production of abrasive materials, calcium carbide and many other types of products.

The English chemist and physicist H. Davy observed an electric glow six years later than Petrov in 1808 [5–7]. In the work «Elements of Chemical Philosophy» (1812), he reported on his experiments with an electric arc. And he did not pretend to their originality and admitted that this was done before him by a foreign physicist. However, for a long time the discovery of a voltaic arc was attributed to him.

Petrov used a variety of electrodes: wood-coal, graphite, copper, iron, silver, gold, tin, manganese, etc. He observed phenomena between electrodes that were in the air, a discharged medium and various liquids. He first correctly determined the degree of electrical conductivity of charcoal, ice, sulfur, phosphorus, vegetable oils, identified their physicochemical and insulating properties, established the insulation value for electrical conductors at high voltage and applied the coating of metal conductors with an insulating layer. The principle of covering the surface of a conductor with an insulating material developed by the scientist is used today for manufacture of insulated wires and cables.

Petrov was the first to determine regularity of an electrical circuit: current force in a conductor increases with increasing thickness, area of its cross section. Plus, he managed to find out that through substances with a large electrical resistance (it was he who again introduced this term into electrical engineering), galvanic-volt liquid (according to current terminology electric current) can flow with increasing number of elements, i.e. increasing the voltage. Thus, Petrov 25 years earlier than the German physicist G. S. Ohm established that the electric current is directly proportional to the voltage and cross-sectional area of the conductor [15].

The scientist studied in detail the influence of temperature on the value of emf of the battery and on nature of phenomena and chemical processes that accompany it. He was convinced that the metal's extreme metal circles serve only as conductors of electricity, its action is based on chemical processes taking place in the galvanic cell between metals (copper-zinc) and the electrolyte, and oxidation and contamination of the surface of metal circles causes weakening of current.

Petrov first applied a parallel connection of electrodes to demonstrate the phenomenon of electrolysis in several tubes with water, vegetable oils, alcohol, etc., which occurs while simultaneously passing an electric current through liquids from one copper-zinc pair. He established the dependence of intensity of glow (glow, spark, arc discharges) on elasticity of the ambient air – material, shape and polarity of electrodes, and also on the distance between them. The length of a spark from a voltaic column in the airless space is much shorter than when discharging an electrostatic machine, and instantaneous charging of huge Leyden batteries by a small voltaic column or their slow charging by powerful electrostatic machines takes place. 30 years later, these phenomena were studied by the English physicist M. Faraday. The chemical effect of current (electrolysis) was applied by the Russian electrical engineer B. S. Jacobi in electroforming and electroplating [16], which are still in demand in polygraphy, medals and so on.

Research of Petrov put him in the ranks of outstanding scientists of the country. In 1803 he was elected a corresponding member, then an adjunct (auxiliary), extraordinary (supernumerary), and in 1815 – an ordinary (full-time) academician in the subject of experimental physics of the Russian Imperial Academy of Sciences. In 1814, Vasily Vladimirovich was appointed the head of the physics cabinet, he directed it until 1828.

About the phosphors of the vegetated kingdom

The English physicist and physician W. Gilbert unsuccessfully tried to electrify metals without isolating them. Therefore, he came to an erroneous conclusion about the impossibility of electrifying metals by friction. In 1804, Petrov, in his third book, «The New Electrical Experiments of Professor of Physics Vasily Petrov», reprinted in 1956, [9], proved the possibility of electrifying isolated metals with friction and described a series of experiments on electrification of mercury and other substances by shaking them in glass vessels. He showed that a particularly effective way of electrifying metals and the human body is by quilting them with fur of some animals.

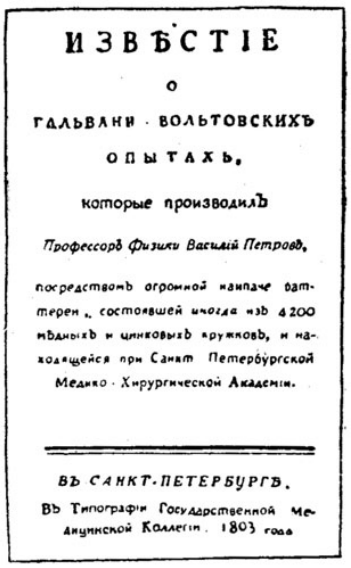
The scientist rightly wrote here about instability of the phenomena of electrization, influence on their intensity, the state of the surface of bodies, their dimensions and temperature, and also humidity of the ambient air. He improved the design of the device for production of static electricity (electrophores), the resin base was replaced with a dried-out soft cloth, folded into four layers and gave a correct idea of generality and difference in manifestations of static and galvanic electricity: they are due to certain physicochemical processes.

To study the phenomenon of static electricity in discharged air and the atmosphere of various gases, Petrov built an electrostatic machine, placed under the bell of an air pump. The thermometer installed there also fixed the intensity of electrical discharges at various temperatures. He discovered an increase in electrical conductivity of air when it was heated and formation of nitrogen oxides in electrical discharges in the air. He carried out research of glow, spark and arc electric discharges in a vacuum. He found the dependence of these phenomena on the material, the shape and polarity of electrodes, the distance between them and the degree of vacuum. He also has interesting experiments on observing the glow of discharged gases when electric current passes through them.

The study of luminescence (glow of phosphorus, etc.) was carried out by L. Euler, T. Grotthus and others. But they did not give quantitative estimates. Petrov continued studies of this phenomenon for 40 years, beginning them at the end of 18th century. His views on the nature of luminescence are contained in the book «On the phosphors of the vegetated kingdom and the true cause of the glow of rotten trees».

He first studied the glow of rotting plants, Ivanov worms, meat and fish, and then phosphor glow. The scientist established that presence or absence of oxygen had no impact on the process of glowing minerals, that their luminescence was excited by another cause – prolonged irradiation with sunlight. He managed to understand the difference between chemiluminescence (glow of certain substances that occurs during chemical reactions), bioluminescence (emission of light by living organisms during their transition from the oxidized form to the ground state) and photoluminescence (emission of substances excited by light). At present, after research by Academician S. I. Vavilov, the luminescence phenomena are made up of one of the optics departments and found application in the form of luminous compositions and gas-discharge light sources in low-pressure electric lamps [19].

For many years, Vasily Vladimirovich headed meteorological research conducted by St. Petersburg Academy of Sciences. In addition to his own observations, he processed the data of meteorological journals that came to the Russian Academy of Sciences from different cities of the country. Numerous physical, chemical and meteorological works of Academician Petrov were published in the editions of the Academy of Sciences («Speculative Research of the Imperial Academy of Sciences» for 1808–1819, «Proceedings of the Academy of Sciences» for 1821–1823 years, «Technological Journal» for 1810–1826). However, many of his works remained unpublished, preserved only in the Archive of the Academy of Sciences or lost.


ИЗВѢСТІЕ

О

ГАЛЬВАНИ - ВОЛЬТОВСКИХЪ

ОПЫТАХЪ,

которые производилъ

Профессоръ Физики Василій Петровъ,

посредствомъ огромной напрасе батареи, состоявшей иногда изъ 4200 мѣдныхъ и цинковыхъ кружковъ, и находящейся при Санктъ Петербургской Медико - Хирургической Академіи.

ВЪ САНКТ-ПЕТЕРБУРГѢ.

Въ Типографіи Государственной Медицинской Коллегіи. 1803 года

Title page of the memoir of V. V. Petrov «News about galvanic-voltaic experiments».

Since 1830, Petrov was forced to almost completely stop doing science, first due to loss of vision, while fighting cataracts in both eyes and had to resort to surgery, and then because of the onset of old age illnesses. He was dismissed from Medical-Surgical Academy in February 1833.

What we have, we do not store

Vasily Vladimirovich Petrov died on August 3 (July 22 old style) 1834 at the age of 73 years. He had the rank of an actual state councilor (a civil rank of the 4th class, which gave hereditary nobility) and was an honorary member of the Erlagen Physico-Medical Society in Germany (elected in 1810), the University of Vilna (elected in 1829) and the Medical-Surgical Academy.

His death passed unnoticed, was not marked either by the Medical-Surgical Academy, where he worked for about 40 years and organized teaching of physics as a separate discipline, or the Russian Imperial Academy of Sciences, where he worked for about 30 years. The scientist did not have a tombstone, there was no reliable portrait until now, and all observations and discoveries remained unknown for more than 50 years.

There are many reasons. If the works of Academician Petrov were printed in Latin, he would immediately become a world famous electrical engineer. In addition, he was not of noble origin, and the German group of St. Petersburg Academy (L. Yu. Krafft (W. L. Krafft), N. I. Fuchs, G. I. Parrot (G.-F. von Parrot), etc.), who enjoyed protection of Emperor Alexander I, went to any tricks, to represent the Russian colleague as a negligent employee.

Krafft refused to submit to St. Petersburg Academy of Sciences Petrov's book «The news of galvanic-voltaic experiments ...», as required by the rules, and in 1805 published an article «On the galvanic experiments», in which he wrote that the discoverer of the electric arc is the mechanic of the academic workshops Mejer .

The commoner was not honored at the time, and even with independent judgments, who openly criticized stagnation, routine and disorder in the Imperial Academy of Sciences. In protest, Petrov defiantly refused to participate in the funeral of Emperor Alexander I in 1825. After that, he was removed from the leadership of the physics cabinet of St. Petersburg Academy of Sciences (Academician in the Department of Applied Mathematics Parrot was appointed as the head), his works were banned for printing.

The works of Petrov 52 years after his death, in 1886, were noticed by the student of St. Petersburg University A. L. Gershun (later a famous professor of physics). During the summer holidays, working in the public library of Vilno (now Vilnius), he found a book by an unknown professor Petrov, «The news of galvanic-voltaic experiments...». Gershun told about his discovery to his comrades and metropolitan physicists. An employee of the laboratory of St. Petersburg University N. V. Popov in 1887 published an article about the find of the student in the journal «Electricity». The works of Petrov began to be studied. It turned out that he had performed a number of valuable studies in various fields of physics and chemistry and that his works were original, advanced for their time, representing not only historical but also great real scientific interest.

In 1893 the Russian Physico-Chemical Society in a special emergency meeting commemorated the memory of Academician V. V. Petrov on the occasion of the hundredth anniversary since the beginning of his teaching career at the Military Medical Academy. In 1902, at the meetings of scientific societies, the centenary of the discovery of the voltaic arc was celebrated, and in 1934 events were organized to perpetuate the memory of the scientist in connection with the centenary of his death.

His grave was lost. Subsequently, almost 100 years later, Professor N. N. Georgievsky finally found the abandoned burial of Petrov at the Smolensk cemetery in St. Petersburg. The grave was put in order and an obelisk monument to the academician appeared on it.

They perpetuated the monument of a fellow countryman in his homeland in the city of Oboyan, where the central square is named after V. V. Petrov.

He initiated a new science – electrical engineering, which has been dealing with electrical and magnetic phenomena for more than two centuries. He was the successor and continuer of M. V. Lomonosov's works in the field of experimental research of physical and chemical processes, as well as in the struggle for independent development of Russian science and culture. And this is his mission we need to honor and remember.

REFERENCES

1. Eliseev, A. A. Vasily Vladimirovich Petrov. Moscow-Leningrad, Gosenergoizdat publ., 1948, 180 p.

2. Kudryavtsev, B. B. Vasily Vladimirovich Petrov. His life and work [*Vasily Vladimirovich Petrov. Ego zhizn' i deyatel'nost'*]. Moscow, Gostekhizdat publ., 1952, 96 p.

3. Petrov Vasily Vladimirovich. *The Great Soviet Encyclopedia*. 2nd ed. Vol. 32. Moscow, GSE, 1955, pp. 595–596.

4. Petrov Vasily Vladimirovich. *Soviet Encyclopedic Dictionary*. Moscow, Publishing house «Soviet Encyclopedia», 1985, p. 993.

5. Veselovsky, O. N., Shneiberg, Ya. A. Essays on the history of electrical engineering [*Ocherki po istorii elektrotehniki*]. Moscow, MEI publ., 1993, 252 p.

6. Shatelen, M. A. Russian electrical engineers of the second half of 19th century [*Russkie elektrotehniki vtoroi poloviny XIX veka*]. Moscow–Leningrad, Gosenergoizdat publ., 1949, 379 p.

7. Shatelen, M. A. Russian electrical engineers of 19th century [*Russkie elektrotehniki XIX veka*]. Moscow–Leningrad, Gosenergoizdat publ., 1955, 432 p.

8. Collection to the centenary of the death of the first Russian electrical engineer Academician Vasily Vladimirovich Petrov (1761–1834) [*Sbornik l stoletiyu so dnya smerti pervogo russkogo elektrotehnika akademika Vasiliya Vladimirovicha Petrova (1761–1834)*]. Moscow–Leningrad, ONTI publ., 1936, 196 p.

9. Petrov, V. V. Selected works on electricity [*Izbrannie trudy po elektrichestvu*]. Ed. by L. D. Belkind. Moscow, Gostekhizdat publ., 1956, 290 p.

10. Grigoriev, N. D. The Shilling Telegraph for Railways. *World of Transport and Transportation*, Vol. 9, 2011, Iss. 2, pp. 184–190.

11. Grigoriev, N. D. Bright beam in front of a locomotive. *World of Transport and Transportation*, Vol. 12, 2014, Iss. 5, pp. 236–245, Iss. 6, pp. 224–237.

12. Grigoriev, N. D. In expectation of Motor Ship with Electric Propulsion. *World of Transport and Transportation*. Vol. 8, 2010, Iss. 2, pp. 176–183.

13. Grigoriev, N. D. He was cutting the rail with the arc... (to the 170th anniversary of Nickolay Benardos). *World of Transport and Transportation*, Vol. 10, 2012, Iss. 2, pp. 192–201.

14. Grigoriev, N. D. Saved bell-ringing (dedicated to 160th anniversary of birth of Nickolay Gavrilovich Slavyanov). *World of Transport and Transportation*, Vol. 12, 2014, Iss. 2, pp. 244–256.

15. Fundamentals of the theory of chains [*Osnovy teorii tsepei*]. Moscow, Energoatomizdat publ., 1989, 528 p.

16. Jacobi Boris Semenovich. Soviet Encyclopedic Dictionary. Moscow, Publishing house «Soviet Encyclopedia», 1985, 1567 p.

17. Academician V. V. Petrov (1761–1834). To the history of physics and chemistry in Russia in the beginning of 19th century [*K istorii fiziki i himii v Rossii v nachale XIX v.*]: Collection of articles and materials. Ed. by S. I. Vavilov. Moscow–Leningrad, Publishing House of the USSR Academy of Sciences, 1940, 250 p.

18. Grigoriev, N. D. Faust curve without Mephistopheles impurities. *World of Transport and Transportation*, Vol. 14, 2016, Iss. 1, pp. 246–254.

19. Grigoriev, N. D. Infinite talent. *World of Transport and Transportation*, Vol. 13, 2015, Iss. 3, pp. 266–281.

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