«WIRES WITH HIGH VOLTAGE TRANSPORT CURRENT»

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ABSTRACT

Dmitry A. Lachinov was born 175 years ago and nothing foreshadowed that a man appeared who would explain the theory of transmission (transportation) of electricity over long-distance via wires and without large losses, using high-voltage currents (over 1000 V), power transformers and a three-phase alternating current system. That was Dmitry Lachinov who introduced mathematical methods into electrical engineering, making it possible to create electric machines not on the basis of empiricism, but due to mathematical evaluation of physical phenomena.

Keywords: history, electrical engineering, Lachinov, electricity transmission via wires, electric machines, generators, engines, batteries for submarine fleet.

Background. *Russian electrical engineer, professor Dmitry Aleksandrovich Lachinov was born on May 22 (old style May 10) in 1842 in the village Lesnoe Konobeevo (according to other sources in Novaya Ostrovka) Shatsky district of Tambov province (now Shatsky district of Ryazan region). He came from an ancient Russian family, leading the genealogy from the voevoda of the middle of XV century G. G. Lachina.*

Objective. *The objective of the author is to consider life and scientific work of a famous Russian electrical engineer Dmitry Lachinov.*

Methods. *The author uses general scientific methods, historical retrospective method, scientific description.*

Results.

To maintain the efficiency – to raise the emf

In 1859, the seventeen-year-old Lachinov graduated from the 1st St. Petersburg Gymnasium and enrolled in the Physics and Mathematics Faculty of the University. Two years later, the university was closed due to student unrest, and in 1862 Dmitry was sent to Germany, where he studied physics for more than two years under the leadership of G. Helmholtz, R. Bunsen and G. Kirchhoff at Heidelberg and T bingen universities. Upon his return to Russia in 1864, Lachinov graduated from St. Petersburg University and in 1865, after defending his thesis, received Ph.D. degree in physical and mathematical sciences.

At the same time, the Department of Physics and Meteorology was established at St. Petersburg Agricultural Institute (now Forestry Academy), where Lachinov became a full-time teacher in 1866 (from 1877 – assistant professor, from 1890 – professor). He organized one of the first laboratories in Russia to conduct practical classes for students in physics, and at the department – a meteorological station.

He worked on creating a dynamo without iron, to study the dependence of EMF on the speed of rotation. The young scientist quickly responded to the requests of electrotechnical practice. As soon as the question arose about the efficiency of the dynamo, he invented a transmission optical dynamometer that made it easy to measure the power transmitted from the primary engine to the generator and was more perfect than the instruments manufactured by Siemens and Halske in Berlin. Lachinov made reports on inventions at the meetings of Physico-Chemical Society at St. Petersburg University, and in 1872 became a member-organizer of the Russian Physical Society.

At the end of 1877 Dmitry Alexandrovich conducted experiments with the phones of the American inventor, Scotsman by the origin A. Bell, determining the resistance of their coils and the sound quality. In the soon-to-be-published publication, he offered dual handsets, that is, it is possible that he was the first who expressed the idea of headphones.

The following year, the Imperial Russian Technical Society (RTS) sent Lachinov to Paris for the World Exhibition. At the same time, he studied the system of professional education in France, about which he made report in March 1879 in the RTS.

Lachinov together with P. N. Yablochkov, V. N. Chikolev, A. N. Lodygin, F. A. Pyrotsky and other electrical engineers was the organizer and the founder of the electrical (VI) department of the RTS. He was elected as an indispensable member of the department, where he became the most active speaker and member of the commission for the preparation of a list of issues, the solution of which is most essential to electrical engineering. In 1880, members of VI department of the RTS organized an editorial office of the electrotechnical journal «Electricity». Lachinov was delegated to assist editors in academic and educational matters. At the first domestic electric exhibition in 1880, where the latest inventions were demonstrated, he became an «explainer» (guide).

From the theory of telegraph lines it was known that the greatest effect in operation of a receiving device is achieved in a consistent mode, when its resistance is equal to internal resistance of a power source together with resistance of connecting wires. But at the same time, the maximum efficiency of the entire plant is 50 %, which is not expedient for high-current power technology. Because of this circumstance, I. Foten, G. Ferraris and many other major specialists lost prospect in scientific and technical searches and stopped their studies only because they could not free themselves from the framework of the theory of low-current circuits.

Lachinov performed a thorough theoretical study of the issue and ways of solving the problem of electric energy transmission. In 1880 he published an article «Electromechanical

work» («Electricity», Iss. 1, 2, 5–7), where he considered the functions of electric machines acting as generators and motors of independent, parallel and sequential excitation, and came to the conclusion about the possibility of transmitting electricity over significant distances through wires without large losses, using high-voltage currents. His main idea was that in order to preserve the efficiency of electric power transmission, it is necessary to increase the speed of rotation of the generator, that is, to raise the EMF proportional to the speed of rotation, and the voltage with increasing distance is proportional to the square root of the resistance of the circuit. A similar conclusion was reached a year later by the French engineer (later Academician) M. Depres, and he confirmed them with experiments in 1882–1883.

The consequence of Lachinov's article – beginning of creation of equipment and power lines with voltage above 1000 V, which caused the use of power transformers, formation of a three-phase alternating current system. In his article, it should be recalled that the scientist proposed to connect several electric machines in series at each end of the line to increase voltage and indicated the possibility of converting heat directly into electricity using thermoelectric batteries. Here he introduced the concept of counter-electromotive force E, deducing it from energy considerations, and gave the formula for DC motors: IR = U – E (I is current in anchor circuit, R is anchor winding resistance, and U is anchor voltage). He replaced empiricism with mathematical methods in a new branch of technology. Electrical engineering at his suggestion became a science based on a mathematical analysis of physical phenomena.

In 1881, Lachinov was a delegate to the Congress of Electricians and represented the Russian Department (RD) at the First World Electrical Exhibition in Paris, where his inventions were demonstrated. For his successful work as the Commissioner General of the RD and for his inventions, he received a bronze medal and was awarded the Order of the Legion of Honor of an officer's degree.

Helped the submarine fleet

The search for methods of incorporating arc illumination lamps into several circuits in a chain of one dynamo in the seventies of XIX century was carried out by many electrical engineers. M. P. Avenarius proposed using his «polarizers» (secondary elements), P. N. Yablochkov – «induction coils» (single-phase transformers) and capacitors. These inventions were patented, demonstrated at exhibitions, but were not widely used. Lachinov was the first to question this theoretical study and came to a series of conclusions, which he presented in 1882 in the article «On parallel introduction of electric lamps» («Electricity», 1882, Iss. 12, 13). He proved the advantages of parallel inclusion of arc lamps, pointed out the possibility of their mixed (parallel and serial) connection, as well as the joint inclusion of arc lamps and incandescent lamps.

In 1884, Lachinov suggested that the city council of St. Petersburg organize a photometric station for systematic control in a competitive environment of various types of lighting among each other, it could perform this function with the help of a convenient and simple photometer developed by him. His theory was based on the law according to which illumination of the surface by a light source is proportional to the force of light and the sine of the angle formed by the rays with the plane, and inversely proportional to the square of the distance. For some time this device had an application.

The scientist simultaneously studied the state of the medium surrounding the conductor when current flows through it, and electrical phenomena in gases and vacuum. The study of the physical properties of gases at various pressures was interesting for him as early as 1865 while he was working on his Ph.D. thesis. Continuing the theme of the voltaic arc and photography, in summer and autumn of 1887 in a physical laboratory, he modeled the forms of atmospheric electricity by differentiating electric discharges in a gaseous medium, photographed or fixed on a bromine-gelatin plate by direct exposure to a spark. In the course of the first experiments, a bright discharge of the spark of the induction coil connected to the capacitors was shot, or – not bright, when the resistance introduced into the circuit gave a prolonged glow discharge. The second and third series of experiments were conducted without a camera. The discharge slid over the surface of the dry bromine-gelatin plate and left a trace on it, which, when developed, was made visible. This was one of the first examples of gas-discharge imaging.

When in 1886 V. N. Chikolev clarified the advantages of parabolic projectors, Lachinov proposed a centrifugal method of manufacturing reflector mirrors based on the use of a parabolic funnel shape, which is formed when a column of liquid mass of rapidly drying cement, gypsum, etc. is rotated at a sufficiently high rate.

In 1887, the scientist published an article entitled «Improvements in batteries or secondary batteries» («Electricity», 1887, Iss. 7), in which he proposed to cover battery plates with spongy lead, which played a significant role in the power supply of ships and the development of the domestic submarine fleet.

In 1888, Lachinov again first proposed an electrolytic method for the production and industrial production of hydrogen and oxygen both at normal and elevated pressures, as well as the use of oxygen-enriched blast in metallurgy and glass production. Engaged mainly in the sphere of technical applications of electricity, he created a galvanic battery of special design, devices for lighting the cavities of the human body (arc diaphanoscope) and detecting defects in electric insulation, an automatic regulator («economizer») of electric lighting, depending on the number of lamps inserted into the circuit and was the author of many other inventions.

In 1895, having learned about the creation of a device for detection and recording of electrical oscillations by the Russian scientist A. S. Popov, Lachinov installed a «storm indicator» or

Dmitry A. Lachinov.

«discharge indicator» (he gave such names to the device) at his meteorological station where the first recordings of electrical discharges of the atmosphere were received and where systematic observations were subsequently carried out for many years. In the second edition of his textbook «Fundamentals of Metrology and Climatology», published in July, the first description of the «storm indicator of Popov», the prototype of the radio receiver, is presented.

With the appearance in 1895 of the first reports on the work of the German scientist V. Roentgen, Lachinov, repeating his experiments, found explanations for new facts and popularized his discovery. To this end, he independently produced the tubes of the English physicist W. Crookes, necessary for obtaining X-rays, and demonstrated them in his lectures.

From the beginning of the 1880s for twenty years, in VI department of the RTS Lachinov was an expert of the Committee for Technical Affairs of the Department of Trade and Manufactories in matters of granting privileges. He considered all the inventions in this field, supported conscientious researchers. The scientist gave feedback on the inventions of domestic and foreign electrical engineers P. N. Yablochkov, V. N. Chikolev, N. N. Benardos, M. Desprey, N. Tesla, V. Simens, T. Edison, etc. He appeared in print with articles defending their rights, was involved in discussions, helped in obtaining privileges, promoted the implementation of inventions bearing new and reasonable.

Conclusion. *In 1899, the St. Petersburg Electrotechnical Institute (now a university) awarded Dmitry Lachinov the title of an honorary electrical engineer. He was among the first of seventeen, who from 1899 to 1903 was awarded this title. Among them are known to the whole world A. N. Lodygin, N. N. Benardos, A. S. Popov, M. O. Dolivo-Dobrovolsky, I. I. Borgman, K. Simens.*

Lachinov died on October 28, 1902 being in his 61st year of life in St. Petersburg.

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