BRIGHT BEAM IN FRONT OF A LOCOMOTIVE

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Grigoriev, Nickolai D. *– Ph.D. (Tech.), associate professor at the department of Electric engineering, metrology and power engineering of Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

Pavel Yablochkov owns one of the most memorable pages in the history of world and domestic electrophysics. In XIX century he became a holder of inventions and patents recognized by the entire civilized world of «Yablochkov candle» and ways to use the effect of «light fragmentation» in the multi-element electric alternating current circuits, etc. Thanks to him, «Russian light» provided a vibrant nightlife to major European cities, gave electric lighting to ships and trains, other public infrastructure facilities. And at the same time the author of the article highlights a dramatic fate of the scientist, early death, unfinished plans and projects.

Invitation from Grand Duke

On the 17th of June, 1877 Yablochkov candle lightened West Indian docks in London, and then Waterloo bridge, halls of Kensington and British Museums, part of embankment of the river Thames, the hotel «Metropol», Hatfield castle, Westgate sea beaches.

It seemed that the darkness stepped back, and electricity took its course. But competitors did not retreat. Nobody wanted to give back anything voluntarily.

Shareholders of powerful British gas companies set all means in motion, up to obvious deceptions, slander and bribes to discredit an illumination method developed by Yablochkov. On their insistence, the British Parliament established a special commission, which included outstanding scientists of the time W. Thomson (Lord Kelvin), J. Tyndall and other persons. They had to consider the admissibility of widespread use of electric lighting in the British Empire.

All failures, which are inevitable in case of the novelty of the case, were exaggerated and were blown about in numerous articles; imaginary catastrophes were described, which might result from the use of electric light. Supporters of gas lighting pointed to the danger of electricity for life, the difficulty of light fragmentation, harmful effects on the eyes, etc. The minutes of the commission stated: «With regard to the electric light, the English ladies are very unhappy: they find that it gives some deadness to their face». Long debates and hearing of witnesses revealed many vigorous opponents of electric candles among members of the commission, considering that in London they were more expensive than gas. Supporters turned out to be in the minority.

Almost simultaneously with England Yablochkov candles lighted rooms of trading firm J. Michaelis in Berlin, National street, Colon square and the ruins of the Colosseum in Rome, Folskgarten in Vienna. With exceptional speed new electric lighting was installed in squares, streets, in ports, shops, theaters and palaces of Belgium, Spain, Portugal, Sweden and other countries in Europe and beyond. «Russian Light» flashed up in San Francisco and on the 26th of December 1878 in Vinemar's stores in Philadelphia (USA), in Rio de Janeiro (Brazil) and cities in Mexico. It appeared in New Delhi, Calcutta, Madras. The Shah of Persia and the King of Cambodia let it lighten their palaces.

None of the inventions in the field of electrical engineering had received such a rapid and widespread occurrence as Yablochkov candles. It was a triumph of the Russian engineer. After his work, it became clear that the electric light is the most convenient, cheapest and promising way of lighting. The candle had little power and was suitable for lighting of small spaces. Groups of such lamps could provide a more uniform light distribution throughout the room than gas lamps and arc lamp projectors. Moreover, price for it decreased rapidly. For example, during two years from March 1878 to March 1880 the price of the candle had fallen by 2 times.

French Patent № 120684, issued to inventor on the 11th of October 1877 proposed capacitors as a stack (block) of metal plates or strips of foil with insulating layers (plates) located between them. They were rolled-up sheets of tin foil, separated by layers of plaster and gutta-percha (a natural waterproof insulation material, the product of condensation or coalescence of colloidal particles of the latex in the Brownian motion). Even metal plates or foil strips were interconnected by a common conductor, while the odd plate or foil strips were interconnected by another one. The blocks could be mounted in parallel or in series. This packet design of capacitors is widespread today.

In addition to that patent on the 12th of October 1878 Yablochkov claimed his rights to the condenser unit from metal sheets coated with an insulating material and immersed in a tank with an insulating liquid to improve electric strength and capacity. This invention was a predecessor of a structure of the oxide electrolytic capacitor with record high specific and absolute capacities patented soon after the author's death. In the electrolytic capacitor dielectric is an oxide layer formed during electrolysis on the metal surface, which is one armature. The other armature is an electrolyte needed for the existence of an oxide layer which thickness is less than a micrometer under smaller voltages.

In magnet dynamoelectric AC machine, on which Yablochkov took out French patent № 119702 in 1877, there were no moving windings and sliding contacts. Magnetizing winding and winding, in which EMF was induced, remained motionless. Ridged iron disk was rotating, changing during the rotation a magnetic flux, penetrating the winding with EMF. This principle of operation of the machine is used in modern inductor alternators.

Low-power generators, designed at that time, geared from transmission shafts via a belt drive, were installed in power plants and prevented the spread of electric lighting. A powerful alternator, developed by Yablochkov, had rotating electromagnets (rotor), the poles of which had a helical (spiral helical) form. He believed that a small angular motion will correspond to significant movement of the magnetic pole, and this will provide an opportunity to use a smaller rotation speed.

Advantages of machines, constructed by Yablochkov in that period of time, over generators of A. V. Siemens and Z. T. Gramm were significant. In Siemens' machine current was generated in a rotating armature, leading to wear of collector-brush gear and flashover due to relatively high voltage in the circuit. In Gram's machine windings, in which EMF was induced, were stationary, but they had a ring shape that made a lot of inconvenience for manufacture of machines and repairing of the windings.

Generators of Yablochkov did not prevent an increase in their size and power, as the system of Gramm. It was possible without stopping the machine, to turn off the damaged coil, remove it and replace it by another one. In fact, they were two-phase synchronous machines with electrically unconnected windings. Yabloch-

kov did not decide to build a multiphase generator with electrically connected windings immediately. He wanted to combine in one machine several individual generators, in the end he got four. It was the first multiphase AC generator, applied in practice for the supply of certain groups of candles and allowing fragmentation of light. Location of the poles on the rotor, stationary armature unit (stator), the current supply to the excitation winding through the brushes and two rings have been preserved in the synchronous machine till present.

At Paris World Exhibition of 1878, Yablochkov's electric lighting system was presented as completely finished for its practical use and was a huge success. His candles and kaolin lamp attracted all visitors. Works of Russian inventor got the interest of members of Paris Academy of Sciences, where a commission was formed, which included well-known scientists A. Saint-Clair-Deville, E. Becquerel, P. Berthelot et al.

It was found that Yablochkov achieved full fragmentation, constancy, and the possibility of separation of electric light in all proportions: small, medium and large. «Proceedings of Paris Academy of Sciences» reported: «Yablochkov candle caused in Paris, as well as, indeed, elsewhere, a movement in favor of electric lighting. We are obliged to it certainly by the fact that electric lighting became a usual way. Equitably in the history of the electric light it should take a very prominent place, which it deserves».

Inventor's name was known all over the world. However, at that exhibition he engaged in persistent and successful controversy with numerous detractors (mostly with representatives of gas companies). He had to refute their false allegations about the shortcomings of the present invention.

The exhibition was visited by Russian Grand Duke Konstantin Nikolaevich (the second son of Emperor Nicholas I), General-Admiral (the highest naval rank), who headed the Naval Department. He was fascinated by inventions and ideas of Yablochkov and offered him financial assistance and cooperation to transfer his activities to Russia.

Night weapon of warships

Becoming famous and very rich (he had a reputation as a millionaire), in 1878, Yablochkov, paid off his creditors in Russia and returned to his homeland. He was invited everywhere, in newspapers and magazines articles were dedicated to him, everywhere his portraits were sold. He together with adorers of electric lighting, among whom there were industrialists, financiers and the military, established in St. Petersburg a stock company «Association of electric lighting and manufacture of electrical machinery and apparatus P. N. Yablochkov- inventor and company». A contract was signed with St. Petersburg electromechanical factory on Obvodny canal on the manufacture of candles and other items. To obtain the right to exploit his inventions in Russia the scientist had to buy French patents № № 112024, 115793 and 120684, paying the Parisian company an exorbitant price with their shares, which otherwise would have brought him a large income. This noble and patriotic act then had a severe impact on his financial position.

For the first time in Russia electric candles were installed in Kronstadt. On the 11th of October 1878, they lit up the quarters of the training crew and squares in front of the house of the commander of the port. In November, their light reached the Winter Palace, and in the spring of next year warships «Peter the Great» and «Vice-Admiral Popov» put out to sea, illuminated by spotlights. The inventor prepared these lighting systems very carefully, as luck would attract the Admiralty, an important customer.

Then the lighting of the Palace and Liteyny bridges across the Neva, a number of factories (Baltic, Obukhov, Izhorsk et al.), sorting-out workshop of Okhta primer plant (thus improving working conditions), rich mansions, some restaurants and other large objects of the Russian capital was carried out successfully. Then eight ball lights shone on the square in front of Alexandrinsky Theatre in St. Petersburg.

In the spring of 1879 the association «Yablochkov-inventor and Co.» began to install of electric lighting in Moscow, Moscow region, Oranienbaum (now Lomonosov in Leningrad region), Kiev, Nizhny Novgorod, Helsingfors (now Helsinki, capital of Finland), Odessa, Kharkiv, Nikolayev, Bryansk, Arkhangelsk, Poltava, Krasnovodsk, Ekaterinodar (now Krasnodar), Saratov and other cities of the Russian Empire.

But the greatest number of lamps with electric candles was installed on warships and in ports of the Baltic and Black Seas, in the factories of the military and naval ministries. Press of the UK at that time wrote that the Russian success in the fight against the Turkish fleet, headed by Admiral Hobart Pasha (Augustus Charles Hobart-Hampden), was largely determined by the skillful application of electric light installations in the Russian navy.

The inventor was a technical leader in the development of plans, projects, installation and establishment of the system of electric ightning everywhere. And again, he, like abroad, had to compete with powerful gas companies, who sought through their supporters to discredit a good work. St. Petersburg City Council, as soon as the contract for electric lighting of Liteyny Bridge expired, refused to renew it. Yablochkov had to repeatedly stand for his candles and debate with his opponents. He talked about the light quality and ease of his candles, insisted that with their help he was able to solve the problem of fragmentation of light and thus make electric lighting competitive with gas. All this took a lot of time and effort.

On the 2nd of April, 1879 Yablochkov made a report «On the electric light» in the Russian Technical Society (hereinafter-RTS). After 10 days, he gave a public lecture, accompanied by numerous demonstrations. On the 14th of April Pavel Nikolayevich was awarded a medal of RTS.

In the same year Yablochkov took a French privilege on electrostatic generator to produce AC or rectified current. That machine consisted of a series of disks with sharp teeth circumferentially, fixed to the rotating shaft. Teeth were in appropriate intervals between several fixed charged disks. Charges, induced in moving disks, were transferred to an external circuit. Modern engineers are working now to further develop these types of generators.

On the 30th of January, 1880 in St. Petersburg, on the first constituent assembly of electrical (VI) department of RTS, he became a permanent member of the society and was elected «candidate for chairman» (deputy chairman). Together with V. N. Chikolev, D. A. Lachinov and A. N. Lodygin the inventor in 1880 initiated the creation of one of the oldest Russian technical journals «Electricity». In the years 1880–1882, Yablochkov together with Chikolev was the first editor-in-chief of the journal.

The world first purely electric exhibition (the year before the future one in Paris), was organized on the initiative of Yablochkov in 1880 in St. Petersburg, a few months after the establishment of VI department of RTS. The exhibition, of course, was illuminated using the system of Yablochkov. Diagrams, charts and explanatory drawings illustrating the methods of candles connection in lanterns and lanterns to each other, other features of the wired networks were installed on the walls. Accessories for electric lighting (candle holders, frosted balls, brackets, etc.) and measuring instruments were exhibited, which were produced by the plant of the stock company «Yablochkov-inventor and Co». Those were the first electrical measuring instruments, not only in Russia, but also in the world. Dynamo-electric machines (generators) were demonstrated feeding the of candles.

In connection with the use of alternating currents to supply Yablochkov candles in 1880 a question arose about the influence of the electrical wires on communication. Electrical Division and a special commission created on its initiative, which also included Yablochkov, conducted a series of experiments, and finally came to the conclusion that even with a very small distance inductive effect of the currents on the wires of communication was so insignificant that it did not affect the operation of telegraph and relay, barely affected phones. This conclusion was of enormous importance at that time, it calmed the Ministry of the Interior, which was in charge of electrical installations, and telegraph administration, which both influenced authorisation procedure concerning wired installations for electrical purposes.

Legion of Honor

At the end of 1880 due to lack of funds, poor technical and industrial conditions and relations of higher police authorities with the Grand Duke Konstantin Nikolaevich, who was accepted unfriendly by high-ranked authorities, Yablochkov, being poor at that time, moved to Paris again. And immediately he began to prepare for the first (official, in contrast to St. Petersburg), International Electrical engineering exhibition, which opened on the 1st of August, 1881. It once again demonstrated the electric lighting system of Yablochkov with AC, transformers, capacitors, and candles. His inventions received the highest out-of-competition assessment of jury. But the exhibition was a triumph of the incandescent lamp, invented in Russia by Lodygin and brought to a marketable product by Edison in the United States. It could be alight for 800–1000 hours without replacement, it could be turned on and off many times.

In 1877, the Russian naval officer A. N. Khotinsky was charged to take in the USA some cruisers, built by order of Russia. He visited the laboratory of Edison and gave him the incandescent lamp of Lodygin and Yablochkov candle with scheme of light fragmentation. Edison made some improvements, and in November 1879 he received a patent for them as for his inventions and established mass production. Yablochkov drew a pen against the American, claiming that he had stolen from Russians not only their thoughts and ideas, but also their inventions. Edison's patent was cancelled by court in the United States. Nevertheless, nobody cancelled the production of incandescent lamps.

Meanwhile, Yablochkov participated in the First International Congress of Electricians, held in 1881 in Paris at the Palais des Champs-Elysées (now the residence of the President of France), and set a system of practical electrical units. Participation in the congress and exhibition served as an occasion to note outstanding achievements of Yablochkov in electrical engineering, he was recipient of the French National Order of the Legion of Honour.

In January 1882 VI department of RTS in St. Petersburg organized the second electric exhibition. It demonstrated all exhibits of the Russian department of Paris Electrical Engineering Exhibition of 1881, and further developments like kaolin lamps of Yablochkov and transformers. Experiments were demonstrated on supplying a number of candles from common alternator through transformers.

In 1882, the illumination of Paris Opéra prospectus with electric candles was replaced by gas burners. Abroad arc lamp was produced with a differential controller named lamp of Hefner-Alteneck (F.H.Ph. F. von Hefner-Alteneck). Transition to more powerful incandescent lamps with a tungsten filament, created by Lodygin narrowed the scope of application of arc lamps. Electric candles due to the low service life, uncontrollability of characteristics, lack of mobility and control got serious contenders, and having caused rapid growth of the electrical industry in the world, five years later it finally gave way to incandescent lamps.

Incidentally, carbon arc lamp is still used in spotlights, film projector and powerful irradiators. The search for more effective means of optical radiation returned to arc lamps, but working on different principles. From the 30s of the XX century light sources using the radiation produced by electric discharge in inert gases or vapors of metals (mainly mercury, sodium) became widespread, e.g. those created under the guidance of academician S. I. Vavilov. Currently, economical low-pressure mercury lamps (fluorescent) are widely used to illuminate premises, facilities, copiers, illuminated advertisement. When connecting the lamp to AC power between its electrodes, an electric current appears, exciting the ultraviolet emission of mercury atoms, resulting in glow of the phosphor layer. Luminous efficiency and lifetime of the fluorescent lamps are several times higher than features of incandescent lamps of the same purpose.

High pressure mercury lamps consist of an internal quartz «burner» and outer glass bulb. In the mercury arc lamp ultraviolet radiation is transferred into a visual area through the phosphor coated on the outer bulb. In it four-electrode burner besides mercury is filled with a mixture of inert gases (argon + 1% neon), providing the minimum value of voltage when an auxiliary and a main discharges arise. Auxiliary electrodes in mercury arc lamp perform ignition of the main discharge, whereby lamps up to 400 W can ignite at temperatures above –25 °C from the line voltage of 220 V without additional impulse devices.

Metal halide lamps of mercury arc lamps with iodides type have a high luminous efficiency (90 lm / W), but cannot work without a pulse ignitor.

The invention of a transparent ceramic shell of polycrystalline alumina with operating temperatures of 1500–1600 °C made it possible to create high-intensity sodium arc lamps. Their igniter gas is xenon; a buffer gas is mercury vapor. Color quality is improved with increasing content of mercury vapor, or the introduction of other elements. Luminous efficiency of these lamps

is 140 lm / W. The newest types are high-intensity sulfur light sources.

Mobile and adjustable semiconductor lamps with LEDs that emit white, orange, yellow, green, blue, cyan, red lights find widespread use; they are more economical and durable than fluorescent lamps. Radiation sources based on LEDs have good performance: they are not affected by pressure changes, mechanical loads and ambient temperature (work from –55 ℃ to 85 ℃), characterized by a long service life (up to 50 000 hours), reliability, environmental friendliness, compactness, easy scheme of switching, electrical safety. To increase capacity and improve light transmission LEDs are assembled in modules.

Patent for automatic battery

In 1882 Yablochkov filed a patent application on the dynamo, that in order to increase EMF at the same speed of rotation its stator axis (stationary coil system) and the rotor (the moving coil system) are inclined to the axis of rotation.

He patented in the same year the motor, which was designed for a very small number of turns, the need for which was caused by the fact that mechanisms applied at that time were adapted to the low-speed steam engines. Then he invented the electric motor called cliptic, capable of operating at DC and AC voltage, and alternator with sweep slots. Now, in synchronous generators slot skewing is also used at the value of slot pitch.

Slots in the stator of the electric machine impair a curve of magnetic field in the air gap between an armature (stator) and an inductor (rotor), because the force lines are drawn on the tooth group. Additional harmonics called tooth harmonics are somewhat superimposed on fundamental harmonic component of the magnetic field of poles and slots. In electrical machines with an integer number of slots per pole-phase a multiple increase in EMF occurs up to the higher harmonics, which are induced by harmonics of the magnetic field close to or divisible by the number of teeth per a pair of poles. At the indicated value of slot skewing EMF of the tooth harmonics of the magnetic field considerably weakens, and EMF induced in the conductors of the armature winding of the fundamental harmonic is reduced only by about 1% due to a slight slot skewing.

Electric machines of Yablochkov did not become widespread, because the inventor did not have sufficient funds to develop their commercial production. He could not, like Edison, bring his developments into business intercourse intending to use received funds for further research, manufacture of devices, experimentation and further practical implementation.

Yablochkov engaged in the development of new electrochemical cells. At first he tried to get electricity by direct consumption of coal in a galvanic cell, bypassing the use of the steam engine. The electrolyte was molten nitrate (ammonium nitrate), poured into the cast iron cylinder and was at the same time a source of oxygen for the combustion of coal and polarizer. A wire basket with coke which then became a cathode, was put into a cylinder. Adding to the nitrate salts of certain metals enabled to adjust the intensity of the combustion process. This dry element generated the current, exceeding the current of liquid electrochemical cell (zinc-carbon primary cell) of R. V. Bunsen, applied at that time.

In another Yablochkov's cell oxygen was produced out of water. Later, the inventor turned to the elements in which the coal was used instead of sodium or other strong oxidized alkali metals. They did not require the presence of liquid and he called them «dry cells». Their effect was based on the oxidation of sodium at room temperature. Sodium serving as a cathode in this case is separated from the coal or other conductor with a plate of the porous insulator. Atmospheric oxygen, oxidizing sodium, penetrated to him through the porous anode and a porous insulator. The rear surface of the sodium plate was covered with a layer of varnish which prevented it from the direct oxidation by the air. The cell with sodium went through several different modifications.

Work with chemical current sources was life-threatening. In 1884, during the experiments with the sodium battery with capacity of 40 horsepower (29,44 kW) ignition of hydrogen caused an explosion, transformed into a fire. Windows were broken in the laboratory; the room was filled with gas. The inventor was almost killed; he began to choke with combustion products and was lying unconscious with a singed beard, when Paris firemen came to rescue him.

A harmful process in electrochemical cells is polarization of the anode, i. e. accumulation of hydrogen near the anode, which prevents the passage of current. Yablochkov used anode polarization to create a special three-electrode cell. In the central part of the cylindrical cell the cathode was a strong oxidizing rod of sodium, the anode was a relatively weak oxidizing zinc cylinder. In the outer part of the same cell the anode was non-oxidizing carbon, the cathode was zinc. Coal permanently polarized, but nevertheless absorbed oxygen from the air, which led to continuous destruction of polarization by compounding oxygen with hydrogen polarizing coal. Yablochkov called this type of electrochemical cell «automatic (or auto-) battery» and patented it in 1885. Then he presented a report on the operating principles of this cell in Paris Academy of Sciences. His battery was a prototype of galvanic cells with «air depolarization», proposed later.

The appearance of electric lighting of Yablochkov's system brought to life electric isolated block-plant for one building (without power transmission over long distances). The first such station was installed in 1876 in Paris, the second one was engineered in 1879 – in St. Petersburg for lighting of Liteyny Bridge (with the participation of the inventor), and the next one was engineered in 1882 for Moscow Lubyanka shopping mall.

In 1885, the scientist suggested centralized generation of electricity and the method of its transmission over a distance by means of high-voltage alternating current. He recommended the use of induction coils to increase the voltage. Six years later, a Russian engineer Dolivo-Dobrovolsky carried out transmission of electric power of more than 75 kW over 175 km with an increase in voltage by transformers up to 15 kV, creating a three-phase AC system. The idea of Yablochkov on a centralized generation and distribution of electric energy then began to be put into practice; the construction of the AC power stations began.

At the third domestic electrical exhibition, which opened in January 1885, Yablochkov's plant exhibited its incandescent lamps of 45W and batteries. For them, the company received the highest award, the medal of RTS.

In 1887, the inventor took out a patent for the method of galvanic depolarization. In the latter types of electrochemical cells designed by him he, using tin coating of the zinc cathode, struggled with its clogging with zinc oxide. Clogging of coal pores was removed by device element of a thin wooden partition with very small porous holes, not carrying contaminating particles of salts to the coal and with power feed of gases to it under the pressure. Subsequently wooden separators began to be used in the construction of lead acid batteries.

A tall man

In 1889, Yablochkov was a jury member in the class XV (precision mechanics, scientific instruments), chairman of the Russian Committee and organizer of Russian Electrical Engineering Department at Paris exhibition. He exhibited 166 candles, demonstrated the use of transformers, and the most advanced versions of the system of electric lighting with candles were shown. But all this could not have any practical implications for him.

At the exhibition the scientist met with a jeweler from the Netherlands, who informed him about the possibility of enrichment on the difference in the price of white and yellow diamonds, mined in the Cape Colony of Great Britain (now provinces of the Republic of South Africa), if a way of decoloration of the latter was found. Yablochkov, who needed financial assets for his major works, began to conduct experiments with chlorine decoloration of yellow diamonds at high temperature.

It is now known that chlorine is a poisonous gas. It exasperates mucous membranes and respiratory system. It reacts with the moisture of the human body to form hydrochloric HCl and hypochlorous HClO acids, and at high concentrations causes muscle spasm of the larynx and tumors of mucous membranes, causing suffocation. When heated, on the light chloride immediatly reacts with hydrogen (a mixture of these gases is explosive). In the heated state chlorine readily reacts with organic compounds to form hydrogen chloride, chlorine organic compounds (with saturated and aromatic hydrocarbons) and carbon (with unsaturated hydrocarbons), which is released in the form of hydrocarbon black.

Chlorine has a strong odor and toxicity, belongs to the second class of dangerous harmful substances. Maximum allowable concentration (MAC) of this gas in the air of the working area is now equal to 1 mg / m^3. People quickly lose the ability to detect the ordor of chlorine in small concentrations, so the value of this gas in excess of the threshold, may not be amenable to immediate detection. Threefold excess of MAC of chlorine during prolonged inhalation of air causes a weakening of lung function, and a five-fold excess leads to disease of the bronchi and creates a predisposition to tuberculosis. Acute toxicity of chlorine causes irritation of eyes, nose, throat, extending to the chest and accompanied by burning pain. Reflex cough starts, sometimes strong, leading to vomiting. Inhalation of large amount of chlorine leads to pulmonary edema, drop in blood pressure and heart failure after a few minutes.

In the experiments chlorine burned mucous membrane of the lungs of the inventor and since then Yablochkov began to choke. Then legs started to swell up. Many years of intensive work, the anxiety caused by the failure of his favorite activity, led to two subsequent consecutive strokes.

Recovered, in December 1892 Yablochkov returned to Russia. In St. Petersburg, he was received coldly, as if he was known to very few people. The attitude of entrepreneurs to him and his ideas changed. Bankers began to consider him as a loser, who was risky to trust money to. He became very ill again, suffered from chest disease and cough.

Yablochkov decided to improve health in his native places with dry and warm climate and went to Atkarsk district of Saratov province, where near the village Koleno he had inherited a small estate Dvoenko. After staying there for a short time, he first moved to Serdobsky district, to an elder sister, whose estate was located in the village Ivanovo-Kuliki, and then in late November 1893 to Saratov, intending to do research.

But his health deteriorated. He had difficulties with breathing, heart weakened, which resulted in a hydrocele (fluid accumulation in the body cavities, subcutaneous tissue of legs and other tissues). Legs had quite swollen and almost did not move. He stopped going out for a walk, although previously he did not enjoy walking either because of being tall (about 2 m), since it seemed to him that too much attention was paid to him.

Neglected, almost destitute famous inventor, the world's first to introduce the practice of electric lighting, lived his last days. On the 31st (or on the 19th according to Russian old style Julian calendar) of March 1894 at age 46, he died. He was buried on the outskirts of the village Sapozhok of Serdobsky district, Saratov region, in the churchyard of the parish church of the Archangel Michael in the family vault.

A lot of papers, notes and memos of Yablochkov disappeared without a trace. Only legends remained on many of his endeavors in aeronautics, mechanical traction on the road (he took a privilege on an electric car). The inventor of the first transformer was first forgotten and only when American and European firms began arguing about patents, people remembered him.

In the judicial debate, among other things, Yablochkov's priority was set in the invention of secondary current generator (transformer), which made it possible to create a modern electric network. The question about who enjoys this priority is likely to be an «idle» issue. But these days, the total power of transformers of raising and lowering substations exceeds almost by 10 times the total installed capacity of synchronous generators of power plants. This fact is eloquent.

In the late 30-ies of the last century, the church in their parish was destroyed. Yablochkov's family vault was damaged also. On the eve of the 100th anniversary of the scientist on the instructions of the President of USSR Academy of Science S. I. Vavilov jubilee committee found his grave after a long search and a survey of local residents in Serdobsky district of Penza region and Rtishchevsky district of Saratov region and upon learning materials in the Saratov regional archives. There in 1952, a monument to Pavel Nikolayevich Yablochkov was erected.

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Координаты автора (contact information): Григорьев Н. Д. (Grigoriev, N.D.) – (495) 684–21–19.
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