SIMPLICITY WILL SAVE THE WORLD

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ABSTRACT

The article is a historical review of the biography of Fedor Pirotsky. The rational ideas of this man not only anticipated the development of rail and electric transport in XIX century, but also played a great role in the fate of electric traction on railways, underground metro lines, the birth of the prototype of the modern tram, as well as those systems of electricity production, which on the basis of the principle «generator-motor» helped solve the problem of its transmission to the consumer over long distances without large losses. The figure of Fedor Pirotsky is also interesting because a general reader knows very little about him. The life of the inventor was full of ups and downs. Some of his ideas were accepted enthusiastically, but many of his proposals were ahead of his time and were duly appreciated only after the death of this outstanding inventor.

Keywords: rail transport, rail conductor, electric train, electric tram, underground, track circuits, electrified line.

Background. *Inventor and electrical engineer Fedor Apollonovich Pirotsky was born 170 years ago – on the 1st of March (17 February old style) in 1845 in a family of lieutenant-healer (military doctor), a descendant of cossacks in the village Sencha of Lokhvitsky county of Poltava province (now Poltava region of the Ukraine).*

Young man of eighteen went to study in Constantine Cadet Corps (secondary military schools for children of nobles) of St. Petersburg, and two years later was transferred to the junker class of Mikhailovsky Artillery School, located in the same place. During his studies, he was able to attend the practice at munitions factories in Finland (then Grand Duchy of Finland was part of Russia), where he set a goal to find an acceptable way to transfer electrical energy from waterfalls of lake rivers, by wires over a sufficiently long distance.

Objective. *The objective of the author is to investigate scientific life, inventions and projects of Fedor Pirotsky.*

Methods. *The author uses historical method, description, analysis.*

Results.

Let the current go by rails

In 1866, after receiving a rank of sub-lieutenant (junior officer rank in the Russian army) Pirotsky was sent to serve in Pechersk fortress artillery of Kyiv garrison. Here he met and became friends with the sub-lieutenant of the engineer battalion, a fan of all that runs on electricity, P. N. Yablochkov, who later became a famous electrician (invented an electric arc lamp without a regulator, a single-phase transformer, a system of electric energy distribution to power light bulbs, worked on the creation of electric generators and chemical power sources). Yablochkov inspired him for inventions and scientific and technical research.

Three years later Pirotsky entered the combat faculty of Mikhailovsky Artillery Academy, after which in 1871 he was appointed an auditor in the department of technical reports and estimates of the Main Artillery Directorate in St. Petersburg. After reviewing the state of production of guns, he developed a system of blast furnaces with triple walls, thus fuel consumption in the smelting of metal reduced. Further – more studying reports of artillery ranges, Fedor in 1874 discovered on the plan of Volkov field a tower for projectors, energy for which was transferred by two thin telephone wires from a low-power electric generator of B. S. Jacobi system, located at a distance of 83 fathoms (177 m). And then he went back to his ideé fixe.

Pirotsky bought two classic commutator machines of Z. F. Gram system with a capacity of 6 hp (4,414 kW). In autumn on the military training ground of Volkov field he conducted a series of experiments on the transmission of electric energy of high power by iron wires fixed via telegraph insulators on wooden poles, from one machine to another at a distance of 93, 5 fathoms (200 m). The earth served as a return conductor. It was the first system «generator-motor» that showed the possibility of transferring to a distance of not only weak currents that was used in telegraphy at that time, but also strong currents.

The experiment confirmed the assumption of the researcher on the economic feasibility of production of electrical energy in places where it can be cheaply obtained due to the presence of fuel or hydraulic energy and its transfer over the line to a remote point of consumption. It was a key to the further development of electrical engineering. Now centralized production of electrical energy is carried out in the world with its subsequent transmission over long distances.

On weekends and after work the experimenter continued to improve the system of production, transfer and conversion of electrical energy into mechanical work, adapting for his needs in 1875 an inactive and abandoned piece of land of resort locomotive railway line Miller of the length of 3,5 versts (3,73 km) leading from the station Sestroretsk to the pier of St. Petersburg port. At the same time, he bought two additional steam engines to drive the generator.

The artillerist-inventor in order to reduce losses in the line held a series of experiments on the transmission of electric current through two isolated railroad rails, the section of which was more than 600 times greater than the cross section of an ordinary telegraph wire. The solution was simple. One of the rails was a direct wire, and the other – the reverse (earth). To

improve conductivity and reduce the resistance of the railway track, he applied electrical butt junctions of direct and reverse wires. To enhance the isolation from each other the two lines of rails of the one track (separated with a scum layer and sleepers) Fedor realized lubrication of the rail base with asphalt.

His ideas on rails as conductor of electric current, tested at that time, are used nowadays. Rail lines of the railway track are the main element of the automatic blocking and cab signaling, electric centralized control of switches and signals, remote monitoring, etc. With the help of track circuits freeness and integrity of the track on hauls and stations are controlled, the possibility of switching under the train is excluded, code signals from the track devices are transmitted to the locomotive, consistency between readings of intermediate signals, automatic control for approach of trains to crossroads, and more are provided.

Dangling legs, others went for a ride

In 1876 Pirotsky forced to rotate the motor, located just one verst (more than 1 km) from the generator of Gramm. His hypothesis about the possibility to use rails of the railways for the electrical transmission of high power at a distance was confirmed. He told about his successful experiments in his article «On the transfer of work of water as the engine over any distance through galvanic current (conductors – rails and wire), including for the movement of trains», published in the «Journal of Engineering» (№ 4 of 1877). The publication about the benefits of water motors with energy transmission over a distance as compared with the use of steam engines, mounted on consumption places was sent to all interested parties. A representative of «Siemens and Halske» sent this article to Germany.

The result was not long in coming: for the Berlin Industrial Exhibition in 1879 the German businessman E. V. Siemens, who had previously engineered a DC engine generator with self-excitation, built a model of the electrified railway line with a separate locomotive and two trailed platforms. The vehicle was used as an attraction. In small open carriages eighteen passengers could travel sitting back to back, dangling legs. The driver sat on the locomotive. Next to two rails, on which a small train was moving, the third one was laid along the sleepers to power the engine with energy (running rails were reverse wire) that as compared with the scheme of Pirotsky worsened the power supply system and made it more expensive.

Pirotsky held further studies in cooperation with an electrician V. N. Chikolev, the author of models of electric arc lamps with a differential regulator. At that time he was a clerk of the Electrical Engineering Department of the Main Artillery Directorate. In 1879, after returning from a long business trip to the Black Sea fortresses Pirotsky proposed the authorities of St. Petersburg a development project of the city tram, which would be set in motion not by horses, but by electricity. But the ambitious project was not adopted under the pressure from the owners of horse-drawn railways.

In January of the new year Fedor Apollonovich together with P. N. Yablochkov, V. N. Chikolev, D. A. Lachinov, A. N. Lodygin and other eminent electrical engineers, experts in the field of telegraphy became one of the first members of the newly created electrical (sixth) department of the Russian Technical Society, in the work of which he always took an active part.

In April Pirotsky during the world's first electrical exhibition in St. Petersburg demonstrated his projects, based on which the second society of urban railways on his proposal built a tram line, and made a report in the Russian Technical Society before a crowded audience on «Power transmission over any distance using galvanic current (conductors – rails and wire)». K. V. Siemens, while rebuilding the imperial telegraph, became interested in the project of the Russian colleague, carefully examined the exhibits, asked him a lot of questions and redrew the schemes. Six months later, in Berlin, his older brother E. V. Siemens spoke on «Dynamo-machine and its application on the railways».

All summer 1880 Pirotsky reworked with own money the heaviest two-story carriage for 40 passengers weighing 400 pounds (6552 kg) of the horse railway, hanging from the bottom under the body to the frame a DC traction motor of shunt excitation with voltage of 100 V, capacity of 4 hp (2,944 kW) with 600 rpm and a gear, rotation of which was transmitted to wheels. It was the first time when a double-reduction gear to its traction motor to the axes of the car on the kinematic scheme was used, further applied in the USA and entitled a tram drive of Sprague. This was a prototype of the modern wheel set of an electric locomotive.

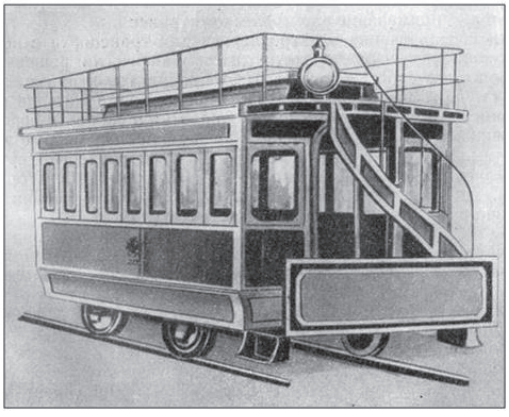
Rail tracks were previously adapted for the transmission of electrical energy. Iron spikes were isolated from sleepers with a special compound and insulating canvas gaskets were laid under the rails. Next to the road on the territory of Rozhdestvensky car fleet a power station with a DC generator was built. Current collection of rails was made through the bandages of sleepers, isolated from car axles. A master switch control allowed to adjust the speed, go forward and backward. Initially, experiments were carried out on the section of the route with the length of 40 fathoms (85 m). It was proved experimentally that the electrical energy can rotate wheels of the horse-drawn carriage moving on rails. Thus, for the first time Pirotsky used running rails for the transmission of electric energy to the moving vehicle.

On September 3, 1880 in the presence of leadership of the Second society of horse-drawn railways the inventor set in motion an empty two-story motor dark blue car № 114, moving at the speed of a horse trotting (up to 12 km / h) without a team of horses. Now it is considered a prototype of the tram. The car moved at different speeds, stopped, resumed running, not turning around, moved in the opposite direction. The same experiment was then repeated with passengers.

Testing and demonstration of the world's first electrically powered tram with passengers, lasted nearly a month on Bolotnaya street of St. Petersburg, attracting the attention of specialists and the public, causing protests from owners of horsecars. The experimental results were published in the «Journal of the Russian Engineering», «Journal of the Russian Physical and Chemical Society», journal «Electricity» (№ 5 of 1880).

The inventor was buried in credit ...

To further improve the design of the tram, Pirotsky had no money. City officials could not help



Pic. 1. Tram coach designed by F.Pirotsky (1876).

him. They had a contract with the owners and shareholders of the society of the horse-drawn railways, giving them a monopoly to transport passengers in the city. They did not want to invest in the refurbishment of the entire economy to electric traction. Therefore, at the insistence of the owners of horse-drawn railways works on introduction of street electric transport in St. Petersburg were discontinued.

In 1881 Pirotsky introduced a scheme of electric railway at the international electrotechnical exhibition in Paris. In the same year he laid the first underground electric cable in St. Petersburg for the transmission of electricity from the cannon foundry to technical artillery school and was the author of the project of a centralized urban underground power network, prompting the authorities of the capital for the construction of the central electric station.

The last place of service of the inventor was Ivangorod fortress of Warsaw Military District. In 1888, for the registration of inheritance of the uncle, he retired as a colonel with cut pensions, not attending few months to achieve 25 years of service, which would guarantee him a full pension. After numerous court cases, which lasted five years, Pirotsky took over the estate in the village Maslovka of Aleshkinsky (Oleshkivsky) County of Tavria province (now Tsyurupinsk district of Kherson region of the Ukraine).

In 1896, the official of the provincial administration discovered, however, that in his track record and all orders a name Perotsky was recorded. Thirty years ago, in the Mikhailovsky Artillery School there was an error in the official documents of the graduate when writing the second letter of the name, which was not corrected for further military service. As a result, he was deprived of his inheritance, and the pensioner had to move out of the estate and move to a military rest home in the city Aleshky (Oleshky).

His pension was barely enough to pay for food and living. Because of suffering a nervous breakdown and miserable existence he had not lived long. On the 12th of March (February 28, Old Style) 1898 Fedor Pirotsky was found dead. He died at the age of 53 years.

Money was not found among his belongings, and friends buried him in a credit against the counted and later sold at auction property. Five trunks, four suitcases and three boxes remained unsold, which contained, in all probability, later lost things (books, paintings, business papers and so on.), that now would be of enormous museum value.

Pirotsky's ideas during his lifetime were accepted abroad, because the problem of the use of electricity for transport existed since the 30s of XIX century.

In 1880, the inventor and entrepreneur T. A. Edison in the USA conducted the first experiments with electric traction on the railway in Menlo Park (New York state). A year later, the company of Siemens brothers began producing cars, the design of which coincided with the Russian project. They opened in Berlin a tram line with length of 2,5 km to Lichterfelde, on which a car was transporting 20 passengers with power transmission to the traction motors similar to the system of Pirotsky without the third rail.

In 1882, at the electrical exhibition in Vienna a tram railway was built, similar to that previously demonstrated in St. Petersburg. A year later streetcar line in Portume (Ireland) was opened for use with a length of 9, 6 km; in 1884 in English Brighton (1, 5 km) and German Frankfurt on the Main (6, 56 km) new lines were also opened. In subsequent years, such transportation became widespread in many parts of Europe and the USA, and in the first third of XX century, the tram because of its technical and economic advantages and environmental friendliness as compared to the horse and steam traction appeared in the most countries of the world.

A tram grasps on the rails

The introduction of the tram in Russia went slowly because of the competition of horse railways. The first electrified monorail line with length of 0, 2 km in Gatchina (now Leningrad region) was built in 1889 by the engineer I. V. Romanov, applying the idea of Pirotsky on the use of electric energy for traction of a rolling vehicle.

On June 14, 1892 in Kiev, despite the objections of the post and telegraph offices, claiming that electricity flowing on the overhead wire and rails would interfere with the work of telegraph and telephone, regular movement of the electric tram was opened. This small revolution was performed by the entrepreneur A. E. Struve, the graduate of the Nicholas engineering school in St. Petersburg. Previously, four and six horses and steaming, rumbling locomotives barely dragged along the rails a little car with passengers on a steep Mikhailovsky hill of the Alexander (Vladimir) descent, connecting the river port to the city center. The situation changed when Struve at his plant in Kolomna organized the engineering and manufacture of electric trams.

In St. Petersburg, the first tramway was built in the winter of 1894–1895 on the ice of the river Neva, because the contract of Joint Stock Company of horse railways, prohibiting the use of electricity for the movement of cars, did not extend only to the river. In winter seasons until 1900 the Russian electrical company of Podobedov operated several tram lines along Nevsky ice.

The cities that opened tram lines were: in Kazan in 1894, Nizhny Novgorod in 1896, Ekaterinoslav (now Dnipropetrovsk) and Kursk in 1897, Orel and Sevastopol in 1898, Moscow in 1899. Next on the list are Yaroslavl (1900), Rostov-on-Don, Tver and

Pic. 2. Tram in the streets of Russia of 19th century.

Smolensk (1901), Pyatigorsk (1903), Vladikavkaz (1904), Tbilisi (1905), Kharkov (1906).

In Russia in the early XX century, there were about 40 tram companies, they are now available in 112 cities, and the total length of tram lines is about 10,000 km. A modern tram car has two electric motors with a total capacity of up to 900 kW, accommodates 120–360 passengers, is equipped with electronic and microprocessor control systems and can reach speeds of 88 km / h.

In 1980s years with the emergence and development of production of lockable thyristors on tram cars actuators were introduced with asynchronous traction motors and short-circuit rotor. They are more reliable, simple in design, easy in maintenance and has a smaller size as compared to the commutator DC traction motors.

In the London Underground, opened in 1863, a fuming locomotive was replaced by an electric locomotive in 1890, thus serving as the impetus for the construction of the subways in the world. The use of electric traction allowed to free tunnels of smoke and soot, improve operating conditions. One of the first underground railway, which was once built in 1896 as an electric one, was underground in Budapest. After that, subways appeared in Paris (1900), Mexico City (1902), Philadelphia (1907), Buenos Aires (1913), Madrid and San Francisco (1919), Barcelona (1924), Tokyo (1927), Moscow (1935).

After the experiments on the electrification of urban transport electrification of suburban, and then of main railways began in the 90s of the 19th century. Motor-car section allowed to evenly distribute the power of the engines along the length of the train, to increase the total weight of trains and their speed even with short lengths of runs. In 1903 in Germany at the railway section Tsosin-Marienfelde of 23 km the first electric motor car of Siemens was tested. In 1929, on the section Moscow-Mytischi traffic of suburban electric trains began. Now such systems are used in diesel trains and locomotives, where the primary internal combustion engines are rotated by electrical generators. From them, the electrical energy is transferred by wire to the traction motors.

Conclusion. *And it all starts from the ideas and insights of such ingenious people like Fedor Pirotsky. He was destined to create, and for the most part without any personal gain and glory. Some exploited his talent; others did not have the ability to see in the simplicity of the proposed solutions continuations worthy for the common cause.*

Time slowly restores justice.

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