THE HISTORY OF AN INVENTION: BORIS ROSING

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ABSTRACT

This invention is used daily by billions of earthlings. But the name of Boris Lvovich Rosing, a professor at St. Petersburg Institute of Technology, whose 150th birthday is celebrated this year, is not widely known. All modern TVs are still working on the principles invented by Rosing. In his diaries, his student, Vladimir Zvorykin, always pointed out that he had only implemented the idea of Rosing.

Keywords: Rosing, history of technology, television, hysteresis, scanning, electro-ray tube, kinescope.

Background. *Boris Lvovich Rosing was born on May 5 (April 23, old style) in 1869 in St. Petersburg in the family of a government official, state councilor for special assignments with the Chief of the General Staff of the Military Directorate [1–9]. As Boris Lvovich wrote in his autobiography: «...My ancestor, Ivan Rosing, who served under Pavel, comes, as can be seen from the official list, from «pharmacy children». Since the pharmacy children were the descendants of those chemists, mineralogists and other foreign scientists who were invited by Peter I to Russia to develop science and technology, I see in this origin some explanation of the desire and thirst for exact sciences, which I continuously felt in myself from an early age».*

Objective. *The objective of the author is to consider life and work of the prominent Russian scientist Boris Lvovich Rosing.*

Methods. *The author uses historical retrospective method.*

Results. *In 1887, after graduating from the gymnasium with a gold medal, Rosing entered the Physics and Mathematics Faculty of St. Petersburg University. The student actively participated in the workshop on physics and repeatedly made presentations. In 1891, after graduating from university with a first degree diploma, he remained at the Department of Physics for two years to prepare for scientific and pedagogical activity and for a professorship.*

Rosing chose research of phenomena occurring in a substance during magnetization reversal as the topic of his dissertation. In the first scientific article «On the Magnetic Motion of Matter», published in 1892 in the journal of the Russian Physico-Chemical Society, he outlined the dynamic theory of magnetism of simple, crystalline and ferromagnetic bodies based on the British physicists J. C. Maxwell and D. D. Thomson's method of physical coordinates and applying Lagrange equations to them. The article explained the phenomenon of magnetization of iron and magnetic hysteresis in it and predicted its existence for diamagnetic bodies having a negative relative magnetic permeability. He assumed that there is a molecular magnetic field created by molecular currents in ferromagnetic bodies. Through a series of experimental studies on the phenomenon of magnetostriction (changes in the length of iron wires placed in a cyclically varying magnetic field), he was able to detect (simultaneously with the Japanese physicist H. Nagaoka) hysteresis in changes in the length of the wires as they were re-magnetized and derive a wire elongation formula. He also conducted research on the phenomenon of thermoelectric current in a circuit consisting of two dissimilar metals, which was a confirmation of the theory of thermoelectricity of the German physicist F. W. G. Kohlrausch.

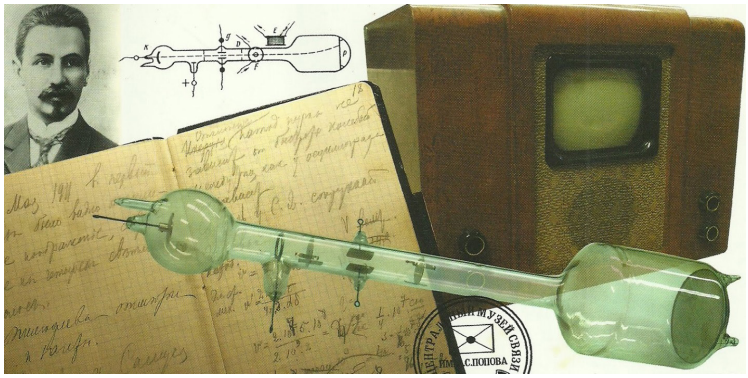
The Department of Physics at St. Petersburg University had no vacancy for an assistant, and in 1893, after being assigned with the academic title of Ph.D. Rosing accepted an offer from another educational institution, St. Petersburg Institute of Technology, to take the position of laboratory assistant at the Department of Physics to conduct practical work and supervise laboratory work of students in the office. In 1898, he was elected as a lecturer to give lectures and conduct practical classes in electricity and electrometry (electrical measurements), and in 1909 he became dean of the electromechanical faculty.

Simultaneously, from 1894, he taught physics and headed a physics office (cabinet) at the Konstantinovsky Artillery School in St. Petersburg. Here the lecturer of electrical engineering K. D. Persky, with whom he had got acquainted at the Institute of Technology, was interested in the problem of transmitting images over a distance.

Since 1906, Rosing lectured on electrical and magnetic measurements at the Women's Polytechnic Courses (in 1915 they were transformed into the Women's Polytechnic Institute), and from 1907 to 1917 he served as dean of the electromechanical faculty.

In 1894–1900, Rosing developed a new battery system with a movable electrolyte layer, created an electrical alarm system with automatic switches for command telegraphs, fire alarms and telephone stations, and dealt with power-saving conversion of thermal energy into electrical one and of electrical into thermal energy.

By that time, the projects of television systems were known, all of them based on mechanical devices for decomposing (scanning) images into elements and selenium photoresistances used as photoelectric converters. But none of the mechanical television systems had been implemented in practice. Since 1897, he spent several years on experiments with mechanical and electrochemical image transmission systems and came to the conclusion that a practical television system should not be built on inert optical-mechanical devices, but on non-inertia systems. Observing how the electron beam of the oscilloscope traces on the screen of the cathode tube, invented in 1879 by the German physicist K. F. Braun, a complex luminous figure, he had the idea of using a cathode ray tube (CRT) as an inertia-free device for reproducing images in a television system. But the image of the transmitted object could appear on the CRT screen only if the photocell current will affect the intensity of



the cathode beam and, therefore, the brightness of the glowing spot. The changes were made to the Braun's tube. The electron beam was vertically and horizontally deflected by magnetic fields from two pairs of mutually perpendicular coils, and the signal from the photocell was fed to a plate of a capacitor placed in a tube between two diaphragms. The electric field inside the capacitor was supposed to deflect the beam vertically when the signal voltage changed, so that the number of electrons passing through the hole in the diaphragm should vary. Because of this, the luminance modulation of the current of the electron beam must occur and the brightness of the points on the screen changes.

This assumption was tested by him in practice in 1902. An oscillographic CRT was applied in the receiving device of the image transmission system. The signals on the tube came from the transmitter in the form of an electrolytic bath with four electrodes connected to the deflecting coils of a CRT. The role of the light beam was performed by a metal rod moved through the electrolyte layer in the bath. The movement of the electron beam on the screen of the tube repeated all the movements of the metal rod, and a luminous spot on the screen traced letters and other shapes.

Then, to transfer and reproduce moving images with different brightness of individual elements (halftone images), he found a way to modulate the intensity of the electron beam of the tube by changing the number of electrons falling on the screen in accordance with the change in the brightness of the elements of the transmitted image. So the prototype of the kinescope was obtained. The system of two multifaceted mirror drums designed by him with horizontal and vertical axes rotating at different speeds made it possible to project the light rays of individual sections of the transmitted image onto the photodetector. The transformation in the transmitting device of the image into electrical signals was carried out not by selenium photoresistance, but by an alkaline photocell with an external photoelectric effect discovered by A. G. Stoletov [10].

In 1907, Rosing filed patent applications in three countries for the invention «A method of electrical transmission of images over a distance». In 1908 and 1909, the discovery of a new method of receiving images in television was confirmed by the patents «New or improved method of electrical transmission over a distance of images and devices for such a transmission» and «A method of electrical transmission of images, and of receiving images using a cathode ray tube» issued to him in England and Germany. The method of receiving television images and the use of CRT in a television system were secured by him in the Russian privilege No. 18076, received in 1910.

As a member of Russian Technical and Russian Physico-Chemical Societies, he was a member of various commissions, and made public reports on «The electrical telescopes and a possible way to carry it out». The television inventor took part in discussions and press releases [11, 12]. He identified the basic requirements for electric telescopes (the term «television» did not exist yet) when transmitting the image of moving objects. To get a solid image in the eye of the observer, it is necessary to transmit signals from all points of the image to the receiver in less than 0,1 seconds. At such a speed, the sensitivity of the transmitting device must be very high, and a high accuracy of synchronization of the image scans in the transmitter and receiver is also required.

From 1906 to 1918, the scientist was a member of the editorial board of the journal «Electricity», where for many years his abstracts and reviews of foreign books on physics, theoretical electrical engineering, electrical measurements, and chemical current sources were published.

Rosing in order to increase the sensitivity and brightness of the screen applied a new type of modulation of the electron beam in the CRT using a pulsed photocurrent at the output of the photocell, which could be enhanced by the resonance phenomenon. In subsequent works, he applied modulation of the speed of the electron beam across the screen without changing its current. The method was based on the dependence of the brightness of the glowing spot on the CRT screen on the duration of the glow. With a decrease in the duration the spot was perceived by the eye as less bright. For such modulation, deflection plates were inserted into the tube. They were powered along with the signal from the photocell in such a polarity that with small signals the speed of the beam on the screen increased, and the screen glowed weakly, and vice versa. In May 1911, at a meeting of the Russian Technical Society, he and his assistant student V. K. Zvorykin, who became an outstanding scientist [13], carried out the world's first television transmission over a distance of primitive signals in the form of a series of points, simple lines and an image of a grid consisting of four bands placed in front of the transmitter lens. In order to see the same image on the screen of the receiving device as in the transmitting device, the inventor constructed an electromagnetic scanning device with the number of lines 12 (in modern television receivers the number of lines is 1125).

He put forward the idea of using a CRT system in a receiving device and scanning (line-by-line transmission) that was practically brought to life [14–16]. In 1911, he patented an improved television

device using electron beam modulation in Russia (Russian privilege No. 24469), Germany (patent No. 244746), England (patent No. 5486), and the USA (patent No. 1161734).

For the invention of television, the greatest scientific and technical achievement in the field of electrical engineering, and for transmission of images over a distance, the Russian Technical Society in 1912 awarded him the Gold Medal and the prize named after the honorary member of the Society C. F. Siemens The laureates of this award were included in encyclopedias and reference books of many countries.

«In fact, Boris Rosing was ahead of his time. The system he worked on required many details that had not yet been developed. At that time, the photocells needed to convert light into electrical energy were at the infancy stage. Although potassium photovoltaic cells have already been described in the literature, the only way to get them was to make them on the own. The vacuum technique was extremely primitive, and it took an incredible amount of time to get the right vacuum. The vacuum pumps we had, were manual, and more than once we had to lift and lower heavy vessels with mercury for several hours to provide a vacuum. Electronic amplifier tubes had just been invented by L. de Forest.., and I had to look for ways to improve them myself. Even the glass for the instruments was of little use: because of its fragility, it was difficult to work with it. We were forced to learn the profession of glassblowing. Yet by the end of my collaboration with Professor Rosing, he had a functioning system consisting of rotating mirrors and a photocell on the transmitting side and a cathode receiving tube with insufficient vacuum that reproduced vague pictures», wrote Vladimir Zvorykin about his teacher.

How did the term «television» appear? Almost until the mid-30s of 20th century, Russian scientists used words that can be translated as: «far-vision or long-vision», «telephoto», «televisioning», «electric vision», «electric telescope». In 1936, in the USSR, published scientific works were entitled as «Fundamentals of far-vision» by V. A. Gurov and «Television» by V. I. Arkhangelsky. Rosing himself adhered to the term «electric telescope». He believed that this phrase more accurately reflects the essence of the process. Moreover, the word «television» became known during his lifetime. For the first time, Konstantin Dmitrievich Persky, a lecturer at the Konstantinovsky Artillery School in St. Petersburg, introduced it into scientific use in a report at the First All-Russian Electrotechnical Congress (1900), and then at the International Electricity Congress in Paris, held from 18 to 25 August, 1900 during International World Fair.

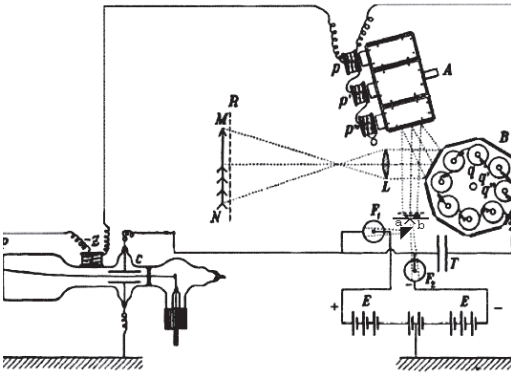
Further work of Rosing was aimed at improving the results achieved. The gas molecules inside the Braun's tube prevented good focusing of the electron beam, which led to image blurring. Therefore, in the years 1912–1914, the gas-filled cold cathode CRT was replaced by a vacuum CRT with an incandescent cathode and magnetic focusing of the electron beam. This was the first practical application of the principles of electronic optics in television. He carried out a theoretical and experimental study of the focusing of an electron beam by a longitudinal magnetic field and derived a calculation formula for determining the focal length of a «magnetic lens» depending on the number of ampere-turns of the coil. Due to the periodic charge and discharge of the capacitance of the line, he was able to obtain deflecting currents, voltages and an electron beam. The inventor together with the lecturer of St. Petersburg Women's Polytechnic Institute M. V. Ivanov developed the technology for production of potassium photovoltaic cells and organized for the first time in Russia their production at a laboratory scale.

During troublous days of revolution and crime in 1917, the wife and the daughter of the scientist left for Kuban region (now Krasnodar region). In 1918, during the winter holidays at the institute, he decided to visit his family in Ekaterinodar (now Krasnodar) for two weeks. But the situation there at the height of the civil war prevented him from returning to Petrograd. Rosing began working as a professor at the department of physics at Kuban Pedagogical Institute. He took part in organization of Kuban Polytechnic Institute (now Kuban State Technological University) and was appointed dean of the electromechanical faculty and professor of the department of theoretical fundamentals of electrical engineering at this institute, later became its vice-rector and rector [17].

In 1920, the scientist created a Physics and Mathematics Society in Ekaterinodar, which was a member of the Russian Physics Association, and became its chairman. He proposed a simplified derivation of the Amsler planimeter formula (a mathematical device for determining the areas of flat figures, as well as for finding the numerical values of certain integrals) using the new vectorial analysis method in Russia. He prepared the reports «On the Photoelectric Relay», «Transformation of the basic equations of the electromagnetic field into a new form», «Building a theory of light and light quanta based on the general solution of the equations of the electromagnetic field of Lorentz». In Kuban region he wrote the book «Electric telescopes (vision at a distance). Immediate tasks and achievements». This final work was published in Petrograd in 1923.

In 1922, Rosing accepted the offer of the Second Petrograd Polytechnic Institute to take the position of professor of the course of electrical and magnetic measurements. He was also invited as a professor of physics at the Women's Polytechnic Institute. In 1924, he returned to the Institute of Technology of Petrograd (which became Leningrad), and also occupied the post of senior researcher at the Leningrad Experimental Electrotechnical Laboratory (LEEL) which was a separate laboratory with a staff of employees.

As far as further developments of television system are concerned, he improved the transmitting



and receiving devices, developed a number of CRT designs, and proposed new methods for modulating the electron beam. In the transmitting device, to increase the image clarity, the number of edges of the drum rotating around the horizontal axis was increased to 48, and the second drum was replaced with a mirror, which with the help of eccentrics made oscillatory movements, moving in one direction for 0,1 seconds. Then it quickly returned to its original position and again started to move in the same direction. Such a scanning system provided the correct alternation of rows without interruptions, and the image was decomposed into 2400 elements.

The design of the deflection voltage for a CRT was also changed. It was removed from the capacitor connected to the current source. The capacitor was charged during rotation of the drum towards the next bound and discharged instantly. A sawtooth voltage was applied to the CRT. In another embodiment, a sawtooth deflection voltage was generated using a circuit with an inductance coil. In the laboratory it was possible to transmit simple images with clearness of 48 lines.

A tube amplifier was used to enhance the photocurrent in an electronic television system.

At LEEL and at the Central Wire Communication Lab, the scientist also worked on improving Galilean binoculars, on photoelectric devices for recording and reproducing sound, photographing sounds, and photoelectric devices for visually impaired persons, facilitating their orientation among dark and light objects.

During these years, being an expert of the Committee for Inventions, Rosing gave a «start» to many domestic inventions. Publishing numerous reviews of achievements in the field of television, he largely contributed to the popularization of the research work.

His pedagogical work at the Institute of Technology continued until his arrest in 1931 (with a break from 1918 to 1924). In his autobiography, «For edification of young people», he wrote: «For successful work an inventor should have the following main qualities: 1) good training in the field of physics and mathematical sciences, 2) great imagination, 3) independence of opinion and the ability not to be discarded by any failures and 4) habit for solitary and hard work.

In 1930, Rosing was repressed by the United State Political Directorate (OGPU) under the Council of People's Commissars (SNK), arrested for financial assistance to counterrevolutionaries (he gave money to a friend in need, an officer of the tsarist army, a lecturer at the Konstantinovsky Artillery School, later also arrested) and in 1931 exiled to Kotlas for three years to a timber mill.

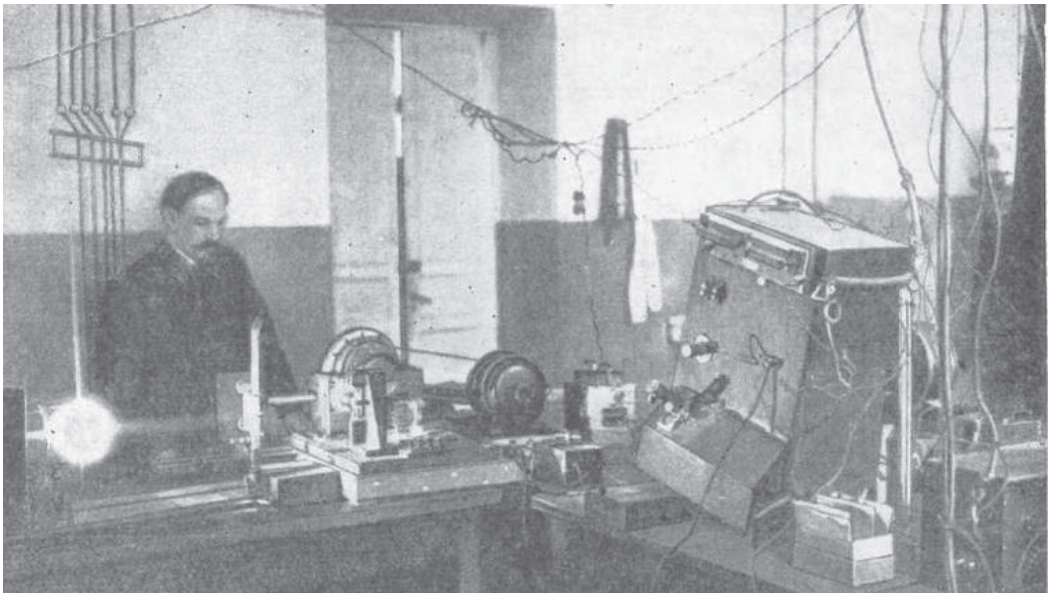
He managed to lecture on physics and write non-fiction articles to local newspapers in exile. In 1932, thanks to the intercession of relatives, friends, domestic and foreign scientific community, he was transferred to Arkhangelsk without the right to work. He carried out scientific experiments on improvement of devices for orienting the visually impaired persons and for photo reading in the laboratory of Arkhangelsk Forestry Institute (now the university) and at the Department of Physics (pedagogical activity of the exiles was prohibited). In the small lunch boxes, the head of the department of physics, Petr Petrovich Pokotylo, brought something to eat from home to a staff member who did not have a salary and lunch coupons.

From the letter of B. L. Rosing to his wife (dated December 18, 1931):

«My dear Asya! My case is in the same position, that is, without movement. I don't know if I will stay here or have to go back, because you will not survive here without being employed and without attachment sheets. The price on the free market is twice as high, than in Kotlas. <…> Yesterday it turned out that administratively deported professors receive right to lecture here only on one condition, from which I feel moral nausea for almost a whole day and want to get out of here as soon as possible. Do they offer it to everybody? < …> Maybe, if I don't get money, then you will send a parcel, but not with the things that it is necessary to cook, since I do not use a kerosene stove, by the way, due to the lack of kerosene».

Boris Lvovich Rosing died of cerebral hemorrhage on April 20, 1933 at the age of 63, while in exile in Arkhangelsk. The circumstances of his death are as follows. While Rosing was returning to the rented apartment, at a sharp turn the tram swung and the food from his small lunch box fell on the coat of the woman sitting next to him. The lady made a scandal, insulting to the scientist, and he only apologized and tried to clean the stained coat with a handkerchief, and at home he went to bed, turned to the wall, and, clutching his head, only repeated: «My God, my God, for what…». The next day he did not go to the institute and died two days later. Rosing was buried in Arkhangelsk at the local Vologda cemetery.

Only in 1957, the presidium of the Leningrad City Court overturned the decision of the on-site session of the OGPU board, claiming the absence of corpus delicti, and Rosing was completely posthumously freed from accusations.



Conclusion. *More than 25 patents, privileges and copyright certificates, as well as over 50 scientific publications, have become the legacy of Rosing. In 1967, he was placed the fourth of the list, following M. V. Lomonosov, D. I. Mendeleev and A. S. Popov, in the poster «10 scientists of Russia who created new fields in science and technology».*

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