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**ДЕРЖАВНИЙ УНІВЕРСИТЕТ ІНФРАСТРУКТУРИ ТА ТЕХНОЛОГІЙ**

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## Evolution of world and domestic production of internal combustion engines

***Abstract.*** *An in-depth and comprehensive study of internal combustion engines creation, the prominent figures' contribution to the formation and development of domestic and world science, remains a crucial task of historical studies at their present stage. The steam engine did not completely solve the energy problem, the humanity was facing. Small workshops and enterprises in the 19$^{th}$ century, which made up a significant part of the industrial sector, were not always able to use it. The small steam engine had a low efficiency. Besides, using such an engine meant high costs and troubles. Small industry required an engine that would take up minimum space and could be turned on and off at any time without much preparation. The article is devoted to highlighting and dividing the development of gas, kerosene, gasoline and diesel engines into stages. The idea of such an engine was first proposed in the early 19$^{th}$ century. The prerequisites for the emergence of each engine type have been considered. The important role of Philippe Lebon as the founder of gas engine design has been shown. Several inventors from different countries worked on the idea of creating engines using various types of fuel. Among them is the Belgian engineer Jean Étienne Lenoir, who suggested starting the engine with an electric spark. The engineer Augustus Otto's role in the development and construction of the first gas engine, which was more economical than a steam engine, has been shown. Thus, all the theoretical and constructive background for inventing a new type of internal combustion engine was there, the designer of which was Rudolf*

*Diesel. He created and patented an internal combustion engine – "diesel", which today remains one of the most economical heat engines.*

***Keywords:*** *internal combustion engine; machinery; diesel; fuel*

## Introduction

These days, many research scientists in the scientific and technical literature address the issues of modern internal combustion engines structure and make forecasts of the development of a power-producing unit for modern cars based on current trends in the environmental and energy field (Bey, 2018, p. 7). Considering the problems of improving the design of piston engines from a historical point of view, the stages of creating various types of internal combustion engines are of interest, as well as the technical problems that arise when they are put into production, analysis of their designs (Berdnychenko, 2018, p. 290). A lot of constructive decisions aimed at achieving the set goals did not justify themselves at certain historical stages due to the state of production technology level at that time. However, with the development of scientific and technological progress in the field of technology, the introduction of advanced achievements in the field of electronics and new materials in engine building, at the next stage of development, advanced ideas have been successfully implemented (Pisarskaya, 2018, p. 370). The purpose of the article is to study the origin and development of internal combustion engines.

## Research methods

During the preparation of the article, chronological, comparative methods of historical knowledge, classification, and systematization of historical sources and bibliographic material have been used (Pylypchuk & Strelko, 2019, p. 20).

## Results and discussions

The progress in the field of internal combustion engines is closely related to the discovery and use of various types of fuel, including synthesized ones. Since the combustion rate of the mixture and the cycle parameters (compression ratio) depend on the fuel used, and to a large extent determines the power indicators of such engines. Illuminating gas became the first such fuel.

On August 26, 1801, a French engineer professor of mechanics at the School of Bridges and Highways in Paris, Philippe Lebon, filed a patent for the design of a gas engine. The driving force emerged after the explosion of the gas-air mixture inside the working cylinder – the mankind at last had an internal combustion engine. The principle of operation of this machine was based on the well-known property of the gas he discovered: its mixture with air exploded upon ignition, with the release of a large amount of heat. Combustion products expanded rapidly, exerting strong pressure on the environment. By creating the appropriate conditions, it was possible to use the released energy in the interests of man. The Lebon engine had two compressors and a mixing chamber. One compressor was supposed to pump the compressed air and the other – compressed illumination gas from the core engine into

the chamber. The gas-air mixture then entered the working cylinder, where it ignited. The engine was double-acting, that is, alternative working chambers were located on both sides of the piston. Lebon cherished an idea of an internal combustion engine, but he was killed in 1804, before he began to realize his invention (Aleksandrov, 1999).

In subsequent years, several inventors from different countries tried to create a workable illuminated-gas engine. Among them was the Belgian engineer Jean Étienne Lenoir. Working at a galvanic plant, Lenoir came to the conclusion that the fuel-air mix in a gas engine could be ignited with an electric spark, and decided to build an engine based on this idea. In 1864, more than 300 of such engines of various powers were already produced. Having become rich, Lenoir stopped improving his machine, and this predestined its fate – it was driven from the market by a more advanced engine created by the German inventor August Otto.

In the late 70$^{s}$ of the 19$^{th}$ century, one of the founders of the Deutz Gas Engine Factory in Cologne, engineer August Otto, managed to build the first efficient gas engine, which was more economical than the steam engines, existing at that time. However, the gas consumption in this engine, which required significant financial investments, was quite large and amounted to approximately 1.5 m³ per hour. Besides, there were very few gas plants, they were concentrated only in large cities, and economically and territorially, these circumstances impeded the widespread introduction of a gas engine into the industry, making it uncompetitive compared to a steam engine.

That is why; all efforts were aimed at finding a fuel that could replace gas. It was decided to use liquid fuel, cheap at that time, oil (The Michigan technic, 1912). However, from the start, it was not oil itself that was applied, but gasoline, as it had a small applicable scope at that time.

Initially, fuel was formed using coil-type evaporators, but as long ago as in 1885, they were replaced by injection pumps, followed by valves, which turned into spray carburettors later. But due to the rapidly growing popularity of gasoline, it was becoming more expensive and therefore unprofitable fuel for engines. In the mid-80$^{s}$ of the 19th century, the question arose of the use of cheaper liquid fuels in engines (Sass, 1962).

Originally, they tried to use oil and fuel oil, but the use of these types of fuel presented great structural difficulties, so they had to take an axe to it and switch to kerosene. So that’s how a kerosene engine design appears. The first kerosene engines that complied with the market conditions can be considered the Spire engine, built in Halle (Germany), and the Priestman engine, built in Hall (England). Both engines had kerosene injection pumps. In the Spire engine, kerosene was injected into the cylinder through a red-hot tube, where it had to evaporate (Bromlej, 1900). In the Priestman engine, kerosene was injected not directly into the cylinder, but into the evaporator, which was heated by exhaust gases.

In 1888, an Englishman James Hargreaves built a self-ignition engine for heavy fuel injected by a pump onto combustion chambers. The Hargreaves’ engine already

contained all the signs of an engine with a hot bulb. At that time, Hargreaves already used a closed injector (an injection nozzle with a needle pressed by a spring, which opened under the pressure of the pump) and injected water into the cylinder to cool the combustion chamber.

Emil Kapitán from Germany, one of the talented engine designers of that time, made a ton of suggestions to solve the problems of heavy-oil engines. His most outstanding work is the proposal to inject two jets of fuel into the combustion chamber from two opposing injectors in such a way that their power in a collision is mutually destroyed and caused fine atomization of the fuel. The ignition of heavy-oil (fuel oil or coal oil) should not be with the help of hot air, but with the help of auxiliary ignition, which was the injection of a small amount of kerosene into a hot earthenware pipe (hot tube). To start the engine, it was only necessary to preheat the tube. But not one of the Kapitán heavy-oil engine projects was completed. This was explained by the lack of funds, but most likely it was because of too much passion for various new Kapitán's ideas and lack of perseverance when he failed in this field (Carpenter, 1902).

Zenlein, equal to Kapitán in genius, was the first to propose a method of air-blast fuel injection in 1884. He patented a kerosene engine with air-blast kerosene injection, ignited by an electric spark. For complete combustion, Zenlein recommended to inject water.

In 1890 in Leipzig, Sviderskyi built a two-stroke engine with a single-stage compressor for fuel atomizing.

In 1887, Otto Köhler, a teacher in Cologne, published "Theory and Construction of a Rational Heat Motor". Using simple thermal calculations as an example, he outlined various cyclic processes of internal combustion engines. For instance, in this brochure, he suggests the design of an engine with compression of a ready-made working mixture, however, this compression pressing should be such as to enable the final temperature obtained due to high compression remain below the self-ignition mixture temperature. For this purpose, the intake valve should have closed earlier than usual. Köhler simultaneously studied engines with high compression pressings of clean air without fuel, which were of great interest at that time, and thus theoretically predicted the working cycle that Diesel subsequently used in his engine. Köhler points out that these engines are popular in the industry due to their theoretically high efficiency. Köhler also stated the ideal Carnot cycle in his work. He calculated an engine with such a cycle and came to the conclusion that "the ideal (Carnot) cycle, apart from difficulties in its implementation, is completely inapplicable for practical purposes" (Timan, 1931).

Thus, there were already all the theoretical and constructive prerequisites for the creation of a new type of internal combustion engine, when the Rudolph Diesel engine appeared (Dizel', 1892). In 1892, Diesel patented an internal combustion engine cycle (Dizel', 1893), herewith he was granted a patent as follows:

1. The internal combustion engine cycle is characterized by the fact that the piston in the cylinder compresses the air or some other gas (steam) so hard that the

resulting compression temperature is much higher than the flash point of fuel. Herewith, the combustion of fuel gradually introduced after the dead centre is so that no significant pressure and temperature occur in the engine cylinder. Following this, after a fuel stop, further expansion of the gas mixture takes place in the cylinder.

2. To carry out the cycle described in paragraph 1, a multi-stage compressor with a receiver shall be connected to the working cylinder. It is possible to connect several working cylinders with each other or with cylinders for preliminary compression and subsequent expansion.

Thus, only isothermal combustion was patented. As can be seen from the Diesel patent, such combustion was meant to keep the combustion temperature low (not more than 700-900°C) in order to avoid water cooling of the cylinders. The heat removed with water after cooling can be used for repeated work (Diesel, 1893). This engine was meant to serve as a rational heat engine and was intended to replace the steam engine and existing heat engines (Gumilevskij, Dizel', 1938).

Rudolph Diesel tirelessly worked on his engine, using his predecessors' and critics' theoretical justifications (Diesel, 1912). Between 1893-1897, accumulating theoretical and practical experience through this process, with the companies of F. Krupp and MAN money, Diesel and his colleagues created an engine, which in its finished design had nothing to do with the "rational", originally patented heat isothermal combustion engine (Bergen, 1991). The foresight of his ideas should be noted, some of which have been implemented these days, and some have yet to be realized. This is the possibility of engine operation on various fuels, including solid, liquid and gaseous, as well as their mixtures. He attributed coal dust and vegetable oils to them. This is also a multi-stage fuel feed, which can be carried out by modern electronically controlled systems. In 1908, Rudolf Diesel's patents expired, and factories all around the world began to manufacture his engine thus testifying the fact of his developments recognition.

## Conclusions

These days, the name Diesel has become outstanding. Even if one considers that Diesel patented in its patent applications the processes far from those embodied in the engine, he nevertheless created and constructed the internal combustion engine – the "diesel engine", which until now is one of the most economical heat engines.

It can be concluded that internal combustion engines are nowadays widespread in various sectors of the national economy. They are especially widely used in land, water and air transport.

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# Еволюція світового та вітчизняного виробництва двигунів внутрішнього згорання

***Анотація.*** *Розгорнуте та всебічне дослідження створення двигунів внутрішнього згорання, внеску видатних діячів у становлення та розвиток вітчизняної та світової науки, залишається актуальним завданням історичної науки на сучасному етапі її розвитку. Паровий двигун не до кінця вирішував енергетичну проблему, що стояла перед людством. Невеликі майстерні і підприємства в XIX столітті, які складали значну частину промислового сектора, не завжди могли ним скористатися. Маленький паровий двигун мав невисокий коефіцієнт корисної дії. Крім того, використання такого двигуна було пов'язано з великими витратами і клопотами. Для дрібної промисловості був потрібний двигун, який був би не громіздкий, який можна було б включати і зупиняти в будь-який час без довгої підготовки. Стаття присвячена висвітленню та періодизації етапів розвитку газових, керосинових, бензинових та дизельних двигунів. Вперше ідея такого двигуна була запропонована на самому початку XIX століття. Розглянуто передумови виникнення кожного типу двигунів. Показано важливу роль Філіпа Лебона, як фундатора ідеї конструкції газового двигуна. Декілька винахідників з різних країн працювали над ідеєю створення двигунів на різних видах палива. Серед них і бельгійський інженер Жан Етьєн Ленуар, який запропонував запускати двигун за допомогою електричної іскри. Висвітлена роль інженера Августа Отто в розробці і побудові першого газового двигуна, який був більш економічний ніж паровий. Таким чином виникли всі теоретичні та конструктивні передумови для нового типу двигуна внутрішнього згоряння, конструктором якого став Рудольф Дизель. Він створив і запатентував двигун внутрішнього згорання – «дизель», який і сьогодні залишається одним з найбільш економічних теплових двигунів.*

***Ключові слова:*** *двигун внутрішнього згорання; техніка; дизель; паливо*

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# Эволюция мирового и отечественного производства двигателей внутреннего сгорания

***Аннотация.*** *Развернутое и всестороннее исследование создания двигателей внутреннего сгорания, вклада выдающихся деятелей в становление и развитие отечественной и мировой науки, остается актуальной задачей исторической науки на современном этапе ее развития. Паровой двигатель не до конца решал энергетическую проблему, стоявшую перед человечеством. Небольшие мастерские и предприятия в XIX веке, которые составляли значительную часть промышленного сектора, не всегда могли им воспользоваться. Маленький паровой двигатель имел невысокий коэффициент полезного действия. Кроме того, использование такого двигателя было связано с большими затратами и хлопотами. Для мелкой промышленности требовался двигатель, который был бы не громоздкий, который можно было бы включать и останавливать в любое время без долгой подготовки. Статья посвящена освещению и периодизации этапов развития газовых, керосиновых, бензиновых и дизельных двигателей. Впервые идея такого двигателя была предложена в самом начале XIX века. Рассмотрены предпосылки возникновения каждого типа двигателей. Показана важная роль Филиппа Лебон, как основателя идеи конструкции газового двигателя. Несколько изобретателей из разных стран работали над идеей создания двигателей на различных видах топлива. Среди них и бельгийский инженер Жан Ленуар, который предложил запускать двигатель с помощью электрической искры. Освещена роль инженера Августа Отто в разработке и построении первого газового двигателя, который был более экономичный, чем паровой. Таким образом, возникли все теоретические и конструктивные предпосылки для нового типа двигателя внутреннего сгорания, конструктором которого стал Рудольф Дизель. Он создал и запатентовал двигатель внутреннего сгорания - «дизель», который и сегодня остается одним из наиболее экономичных тепловых двигателей.*

***Ключевые слова:*** *двигатель внутреннего сгорания; техника; дизель; топливо*

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# The life and scientific activity of Ukrainian astronomer V. M. Grigorevsky (1930-1981)

***Abstract.*** *In 2020, the scientific community will celebrate the 90th birthday of Vitaly Grigorevsky – the Ukrainian astronomer, a specialist in satellite astronomy, a representative of a scientific school of an outstanding Ukrainian scientist, corresponding member of the Ukrainian Academy of Sciences, a director of the Odessa Astronomical Observatory – a professor Vladimir Platonovich Tsesevich. In the article on the basis of complex use of biographical method and methods of bibliographic and source analysis the basic milestones of life and scientific activity of Vitaly Grigorevsky are investigated. The Kherson, Odessa before-Chisinau, Chisinau and Odessa after-Chisinau periods of the scientist's life and work at the Odessa and Chisinau State University, Odessa Technological Institute named after M. V. Lomonosov. The basic directions of scientific researches of the scientist are defined: physical processes in semi-regular variable stars, photometric researches of artificial satellites of the Earth, research of geometry and motion of artificial satellites of the Earth and small planets, optimization of technological processes by mathematical methods with use of electronic computing methods. The contribution of Vitaly Grigorevsky to the formation and development of a new direction of scientific research in the 1960s - photometric observations of artificial satellites of the Earth is shown. The international aspect of Vitaly Grigorevsky's scientific and organizational activity and his work in the Commission on Multilateral Scientific Cooperation between the Academies of Sciences of Socialist Countries are covered. The activity of Vitaliy Grigorevsky as the initiator and coordinator of cooperative research in the field of photometric observations of artificial satellites of the Earth under the SPIN program was noted. The SPIN program included the stations of the People's Republic of Bulgaria, the Czechoslovak Socialist Republic, the Hungarian People's Republic, the German Democratic Republic, the Polish People's Republic, the Soviet Union and the United Arab Republic (Egypt). The little-known facts about the scientist's biography are covered.*

***Keywords:*** *Odessa Astronomical Observatory; Chisinau; photometric observations; artificial Earth satellites; SPIN*

## Introduction

Doctor of Physical and Mathematical Sciences, Professor Vitaly Grigorevsky (1930-1981) – the Ukrainian scientist who worked in the field of classical astronomy and satellite astronomy, a representative of the scientific school of the corresponding member of the Academy of Sciences of the USSR, Doctor of Physical and Mathematical Sciences
– Professor Tsesevich. With the advent of the space age, V. M. Grigorevsky was one of the initiators of photometric observations of artificial Earth satellites (AES) and made a significant contribution to the organization and development of photometric observations of AES in Ukraine and in many countries of Eastern Europe. However, scientific and scientific-organizational activity of V. M. Grigorevsky, with the exception of several works of his colleagues (Mandel, 1995; Karetnikov, 2005), has not received adequate coverage in domestic and foreign historiography.

The purpose of this study is to analyze the basic stages of life and scientific activity of the astronomer Vitaly Grigorevsky (1930-1981) and to reveal the conditions of the scientist's scientific outlook on the basis of the analysis of archival sources and published works.

## Research methods

The methodological basis of the study was the principle of historicism, which provides consideration of the historical events under study in their relationship and development, and the principle of objectivity, orienting to a comprehensive analysis and reliable assessment of historical facts. The complex use of the biographical method and the methods of bibliographic and source analysis made it possible to explore the life and creative path of Vitaly Grigorevsky, to identify and characterize the main periods in the life and scientific activity of the scientist.

## Results and discussion

Vitaly Mikhailovich Grigorevsky was born in Kherson on November 7, 1930 in the family of Mikhail Ivanovich and Nadezhda Ivanovna Grigorevsky (Archive of ONAFT, p. 5). This city has passed the childhood and youth of the future scientist, who have fallen on the difficult years of war, occupation and post-war famine. In early years V. M. Grigorevsky became ill with polio, the effects of which remained for life, but at the same time tempered his character and formed an extraordinary personality. V. M. Grigorevsky was a well-developed young man. He read a lot, was fond of poetry, music, opera, painting, sports (Mandel, 1995), studied foreign languages throughout his life - he was fluent in English, French, German, Moldavian (Archive of ONAFT, p. 3).

In 1949 V. M. Grigorevsky became a student of the mathematical department of the Faculty of Physics and Mathematics of Odessa University (Archive of ONAFT, p. 5). At the University of V. M. Grigorevsky became fascinated with the study of variable stars – this topic was developed in Odesa in 1944 by his scientific adviser

V. P. Cesevich and the vast majority of his students began their research with observations of variable stars (Hrushytska, 2017; Hrushytska, 2018). The first scientific work of V. M. Grigorevsky's "Minima X Trianguli" was published in the Astronomical Circular in 1952, when he was still a third-year student. While he was in student practice at the Abastuman Observatory (Georgia), V. M. Grigorevsky became interested in a new field of research at the time
– polarimetric observations of stars, namely the darkening of the Beta Lyra variable. This research is dedicated to one of the first scientific publications of the scientist "Polarization of Light Beta Lear" (Mandel, 1995).

By the decision of the State Examination Commission of June 25, 1954, V. M. Grigorevsky was awarded the qualification of an astronomer and awarded the diploma with distinction № 926531 (Archive of ONAFT, p. 6). After graduation V. M. Grigorevsky remained at the university as a senior laboratory assistant at the Department of Theoretical Physics and Astrophysics, and in 1957–1960 he studied at the graduate school of the Department of Astronomy of Odessa State University (Archive of ONAFT, p. 5).

At first V. M. Grigorevsky was enrolled in a postgraduate course in the field of research - physical processes in semiregular variable stars. However, in 1957 there were events that rapidly changed the basic direction of his scientific research. At this time, the Odessa Astronomical Observatory (OAO) launched an active activity in preparation for participation in the International Geophysical Year (IGY) programs, in particular began training and, after launching the first Soviet satellite, actively participated in observations of artificial Earth satellites (AES) (Mandel, 1995).

The peculiarity of the AES, in contrast to the natural celestial bodies, was the relatively rapid change of orbital elements due to the resistance of the atmosphere and the deviation of the Earth's gravitational field from the spherical one. Studies have shown that atmospheric resistance is a complex function of many parameters, whose role could only be ascertained by high-precision satellite observations (Masevich, 1961).

Even during the observation of the first missile launcher of the first AES, many Soviet and foreign observers paid attention to the fluctuations of its brilliance with an amplitude of about 5-6 stars. Regular targeted photometric observations of the AES were initiated at the initiative of V. P. Tsesevich in OAO in December 1957 and V. M. Grigorevsky became one of the most active participants in this program.

In March 1958, other Soviet satellite tracking stations were included in these observations of the second Soviet satellite, and the brightness of the third Soviet satellite was observed literally all over the world - in the USSR, USA, Poland, Australia, Bulgaria, Germany, the Czech Republic and others (Grigorevskiy, 1968). V. P. Tsesevich, on the basis of the analysis of a number of observations of the glare of a rocket-carrier of the third Soviet AES, conducted at different stations, but concerning the same orbit coil, developed a theory that allowed to establish the true period of "tipping" of the rocket body and axis position "overturning" in space (Leikin, 1959). Optical observations of the satellites have been an important part of

the program of extra-atmospheric studies of the upper layers of the atmosphere and outer space, and since 1958 the topic "Optical observations of the AES" was included in almost all agreements on scientific cooperation between the Science Academies of socialist countries (Masevich, 1961).

In April 1959, V. M. Grigorevsky participated in the Second All-Union Meeting of Heads of Visual Observation Stations of the AES, which was convened by the Astronomical Council of the USSR Academy of Sciences to discuss directions for further work and exchange of accumulated experience, and was held in Moscow on April 15–17. V. M. Grigorevsky informed about preliminary results of processing of observations of light of the second Soviet AES (Leikin, 1959).

Next year V. M. Grigorevsky completed his postgraduate studies and received a diploma from the University of Chisinau, where he worked at Department of Applied Mathematics (Archive of ONAFT, p. 5).

In 1961, V. M. Grigorevsky headed the optical surveillance station of the AES at Chisinau State University. The station was equipped near the university, in the former city water tower, and is equipped with military binoculars TPZ and TKK, stellar maps of Mikhailov, chronometers, chronographs and other equipment. According to the accuracy of the obtained observation results, the Chisinau station was among the top ten best stations for monitoring the AES operating in the USSR. Later V. M. Grigorevsky has obtained permission for construction of the Astronomical Observatory of the university outside the city in the Codra Reserve (50 km from Chisinau) and for the purchase of the necessary equipment (The development of astronomy in the Moldavian SSR).

In 1962, V. M. Grigorevsky under the guidance of Professor V. P. Tsesevich defended his Ph.D. thesis on the subject of "Fluctuations in the brightness of elongated artificial satellites of the Earth." The defense took place at the Main Astronomical Observatory (MAO) of the USSR Academy of Sciences (Archive of ONAFT, p. 13). By the decision of the Council of MAO of the USSR Academy of Sciences of April 20, 1962 (Protocol No. 7) V. M. Grigorevsky was awarded the academic degree of Candidate of Physical and Mathematical Sciences and issued the Diploma of Candidate of Sciences MFM № 001385 (Archive of ONAFT, p. 7).

In 1963, V. M. Grigorevsky was the coordinator of one of the first US-based satellite research collaborations when it was organized to observe the filling of an American Exo-2 balloon with gas when it enters orbit. For this purpose V. M. Grigorevsky, under the auspices of the Astronomical Council of the USSR Academy of Sciences, organized expeditions to the places over which the first turns of the orbit of this AES lay (Mandel, 1995).

In Chisinau V. M. Grigorevsky supervised works on the list of the most important on the national subject, was a member of the Commission on Multilateral Scientific Cooperation between the AN of the socialist countries, he was elected a member of KOSPAR (UNESCO) and IAU MAC (Archive of ONAFT, p. 11). While V. M. Grigorevsky was working at Chisinau State University, he initiated international cooperative research in the field of photometric observations of the AES and proposed for this purpose the SPIN program. The main objective of this program

was to obtain photometric data on the deceleration of the GCC rotation by the Earth's atmosphere and magnetic field; study the changes in this slowdown due to changes in solar activity; determination of the density of the atmosphere by slowing down the rotation of the satellite. By order of the Multilateral Cooperation Commission of the Academy of Sciences of the Socialist countries V. M. Grigorevsky was appointed as a Coordinator of the work under this program in 1965 (Masevich, 1968; Grigorevskiy, 1968). In the same year, by Decision of the Higher Attestation Commission of March 13, 1965 (Protocol No. 14 / II) V. M. Grigorevsky was approved in the rank of associate professor in the Department of Applied Mathematics (Certificate No. 023980) (Archive of ONAFT, p. 8).

Cooperative photometric observations under the SPIN program were started in 1966. The observations were attended by the stations of the People's Republic of Bulgaria (No. 1102 – Stara Zagora), the Socialist Republic of Romania (No. 1132 – Cluj) and the Soviet Union (No. 1023 – Kiev, No. 1024 – Chisinau, No. 1027 – Krasnodar). In 1967, the composition of participants was expanded by stations # 1115 – Prague (Czechoslovakia), № 1185 – Rodevish (German Democratic Republic), № 1040 – Riga, and № 1092 – Kirov (USSR), but for a number of reasons the Cluj station left. In 1968, 6 more stations from Hungary, the GDR, the Polish People's Republic, the USSR and the United Arab Emirates joined the photometric observations. On the basis of the materials of the results of the GCC observations conducted at these stations, I. M. Panich, V. M. Grigorevsky and V. O. Vorobyova developed a method of visual photometric observations, which allowed to improve the accuracy of determining the values of the period of change in the brightness of the satellite (Panich, Vorobyova, & Grigorevsky, 1969).

In the first three years after the start of SPIN, the necessary material was obtained to observe the relationship between solar activity and changes in the rotation period of the satellites, as well as to study the orientation of the satellites. Theoretical studies of aerodynamic, electromagnetic and other forms of deceleration of satellites have considerably expanded. V. M. Grigorevsky and colleagues conducted the first specially installed parallel studies of the periods of rotation and processing of the satellite 65-11-4 based on the results of observations obtained in accordance with the international programs SPIN and INTEROBS (Masevich, 1968; Grigorevsky, Panich, & Vorobyova, 1968; Grigorevsky, Vorobyova & Panich, 1972).

The INTEROBS program was proposed by Hungarian astronomers M. Ill and I. Almar. It allowed the use of geometric methods in determining the coordinates of a low-orbiting satellite and with acceptable accuracy, then to determine the period of rotation of the satellite around the Earth at an interval of 1-2 days. This made it possible to investigate the relationship of short-term variations in atmospheric density with solar and geomagnetic changes (Masevich, 2005). Observations made by satellite from 1965-11-4 at the same time to the INTEROBS and SPIN programs provided a unique opportunity to simultaneously study changes in the orbital and rotational speeds of the same object, as well as to compare these changes with each other and with changes in solar activity and different geomagnetic characteristics (Grigorevskiy,

Kasimenko, Panich & Vorob'yeva, 1968). In 1968, a Satellite Observer Conference and Conference was held in Chisinau to discuss the goals and results of the SPIN program. A. G. Masevich, a Head of the Commission on Multilateral Cooperation of the Socialist Nations Academy of Sciences on the Problems of Scientific Research on the basis of the AES Observations (Shustov, Dluzhnevskaya, Rykhlova & Tutukov, 2018) approved the work of the staff of the Chisinau station monitoring the AES and the work of the station chief V. M. Grigorevsky. It was noted that the Chisinau station not only led and coordinated international work on the SPIN program, but also did a lot to implement it. Thus, more than half of all observations on the SPIN program in 1965–1968 were conducted in Chisinau, the staff of the station published dozens of theoretical and experimental works with the results of the SPIN (Masevich, 1968; Grigorevskiy, 1970).

In the report of the chairman of the organizing committee V.M. Grigorevsky noted that determining the orientation of the satellite according to photometric data, which was the content of most theoretical works, does not exhaust all the information that can be obtained from photometric studies of satellites. On this basis, the scientist identified a number of major problems that can be solved by satellite photometry, in particular:

- the study of the shape of the satellite surface;
- the study of reflective properties of the satellite surface and their changes over time based on colorimetric and polarimetric observations;
- the study of the vertical distribution of ozone in the Earth atmosphere, as well as the detection of aerosols of terrestrial and cosmic origin at different altitudes in the atmosphere – by photometric observations of satellites as they enter the Earth's shadow.

The determination of satellite orientation: in the case of light scattering on its surface; when the mirror is displayed; in the mixed case (non-spherical scattering indicator); with specially designed mirrors or converters. It has been noted that the determination of orientation by photometric data is the main method for inactive satellites (Grigorevskiy, 1968).

The use of photometric data allowed us to develop methods for determining the orientation of elongated and cylindrical satellites. The relationship of the satellite's rotation period with solar and geomagnetic factors was established and synchronous changes of the satellite's rotation period under the influence of variable solar activity were detected (Grigorevskiy, 1968; Shmelev, Grigorevskiy & Shmeleva 1969). The writings of Grigorevsky, Shmelev and Shmeleva (1968; 1973), Grigorevsky and Bukhbinder (1967) show that to determine the density of the atmosphere it is necessary to take into account the influence of the aerodynamic forces and the magnetic field of the Earth on the rotational motion of the AES and proposed methods for determining the density of the atmosphere.

The inclusion of Egyptian astronomers in the SPIN (Soviet Egyptian Tracking Station, OAR) program has provided photometric observations during the winter months and has the ability to investigate seasonal effects in slowing down the rotation

of satellites (Grigorevskiy, 1968). In 1970, V. M. Grigorevsky co-authored with G. M. Shmelev and V. O. Vorobyov published an article in Washington on the results of photometric observations under the SPIN program "Fhotometric Observations of Satellites and the SPIN Program" (NASA TT F-12. 1970. March. Washington. USA). And in 1971, at the 14th COSPAR meeting in Seattle, June 29, in Seattle, a report was co-authored with INTEROBS Program Coordinator in the USSR, USSR Astronomical Council Representative T. V. Kasimenko "Investigation of the Parameters of the Upper Atmosphere by Simultaneous Optical and Photometric Observations of Satellites" (Archive of ONAFT, p. 16, 17).

In 1970, V. M. Grigorevsky returned to Odessa University, where he worked as an associate professor of the Department of Astronomy, carried out active educational work with students, developed and read a new special course "Satellite Astronomy", which was based on the latest achievements of space exploration and contained the results of the work. In parallel in 1971-1976 Grigorevsky was the head of the monitoring station of AES №1036 at the Odessa State University Observatory. In OAO V. M. Grigorevsky started the AES Research Sector, which later gained the status of the Space Research Division, and headed until 1976 (Archive of ONAFT, p. 26; Mandel, 2005).

At the same time in Chisinau, Ion Panich was appointed as the head of the AES monitoring station, a former graduate student of V. M. Grigorevsky, who in 1973 under his leadership defended his thesis on photometric studies of the AES (The development of astronomy in the Moldavian SSR; Archive of ONAFT, p. 20)

Since 1969 V. M. Grigorevsky conducts active research work on the contractual topics. During the period 1969-1974 under the scientific guidance of the scientist, three contracts were executed, in the other two he participated as the responsible executor. In 1971-1975, V. M. Grigorevsky led a large contract work that was of defensive importance (Archive of ONAFT, p. 23).

In 1973, Grigorevsky defended his doctoral thesis on the theme: «Photometric observations of satellites and their application» (Karetnikov, Grigorevskiy, p. 348; Archive of ONAFT, p. 5). By the decision of the High Attestation Commission of September 13, 1974 (Protocol No. 27 c) V. M. Grigorevsky was awarded the degree of Doctor of Physical and Mathematical Sciences, and on October 21, 1974 was awarded the diploma of Doctor of Science at number MFM № 002207 (Archive of ONAFT, p. 9).

In 1976, V. M. Grigorevsky startscto work at the Odessa Technological Institute named after M. V. Lomonosov was appointed to the Department of Higher Mathematics.until the end of his life, which ended in 1981. On September 1, 1976 he was elected as a professor, and since February 10, 1977 he was a head of the Department of Higher Mathematics (Archive of ONAFT, p. 20). By the decision of the Higher Attestation Commission under the Council of Ministers of the USSR of July 21, 1978 (Protocol No. 24) V. M. Grigoresky was awarded the academic title of Professor in the Department of Higher Mathematics (Certificate of Professor PR No. 004023) (Archive of ONAFT, p. 10).

At the Odessa Technological Institute named after V. M. Lomonosov V. M. Grigorevsky continued his active scientific work on the study of the geometry and motion of the AES and small planets, optimization of technological processes by mathematical methods with the use of electronic computing methods (Archive of ONAFT, p. 20). Applying the methods used to determine the periods of alternating stars and satellites to photometric observations of small planets, in particular, Eros, determined the periods of rotation of small planets relative to the center of mass and the orientation of the axis of rotation in space (Mandel, 1995). The scientist involved in the scientific work of the students of the institute and supervised the execution of the contractual topics (Archive of ONAFT, p. 20).

V. M. Grigorevsky lived in Odessa at: 39/2 V. Tereshkova Street, apt. 95. Wife – Valentina Vorobyova, born in 1933, worked as a research associate at the Odessa State Univercsty, participated in research with her husband and co-authored a series of collaborative scientific papers on photometry of AES (Archive of ONAFT, p. 4).

**Conclusions**

So, V. M. Grigorevsky made a significant contribution to the development of photometric studies of the AES in Ukraine. In the life and creative activity of V. M. Grigorevsky can be distinguished the Kherson, Odessa before-Chisinau, actually Chisinau and Odessa post- Chisinau periods.

In Kherson, the formation of the personality of the future scientist took place and the formation of a character tempered with the fight against severe illness, war fever and difficult post-war living conditions.

The before-Chisinau period of creative activity of V. M. Grigorevsky is affiliated with the University of Odessa, where he received his higher education and first work experience, he completed his postgraduate studies. It was during this period that his joint work with V.P. Tsesevich identified the main directions of scientific research of the scientist - the study of variable stars and photometry of the AES, which later became the main scientific direction from which V. M. Grigorevsky.

The Chisinau period in the creative biography of the scientist lasted almost 10 years (1960–1970) and was one of the most successful in scientific activity. During these years V. M. Grigorevsky finally formed as a scientist, successfully continued his work on photometric observations of the AES, gained invaluable experience of international scientific cooperation and recognition as one of the leading scientists of the world in the field of AES photometry.

In the post-Kishinev period of creative activity V. M. Grigorevsky worked at the Odessa University and the Odessa Technological Institute named after M. V. Lomonosov, broadening the direction of his own research. An important place in the scientific activity of V. M. Grigorevsky's research work was held on a contractual topic that was of defensive importance during this period.

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## Життя й наукова діяльність українського астронома В. М. Григоревського (1930-1981)

***Анотація.*** *У 2020 році наукова громадськість буде відзначати 90-річчя з дня народження Віталія Григоревського – українського астронома, фахівця в галузі супутникової астрономії, представника наукової школи видатного українського вченого, члена-кореспондента Академії Наук УРСР, директора Одеської астрономічної обсерваторії, професора Володимира Платоновича Цесевича. У статті на підставі комплексного використання біографічного методу та методів бібліографічного й джерелознавчого аналізу досліджено основні віхи життя та наукової діяльності Віталія Григоревського. Розглянуто херсонський, одеський докишинівський, кишинівський і одеський післякишинівський періоди життя науковця та його трудову діяльність в Одеському та Кишинівському державному університетах, Одеському*

*технологічному інституті ім. М. В. Ломоносова. Визначено основні напрями наукових пошуків вченого: фізичні процеси у напівправильних змінних зірках, фотометричні дослідження штучних супутників Землі, дослідження геометрії і руху штучних супутників Землі і малих планет, оптимізація технологічних процесів математичними методами з застосуванням електронно-обчислювальних методів. Показано внесок Віталія Григоревського у становлення та розвиток нового для 60-х років минулого століття напряму наукових досліджень – фотометричних спостережень штучних супутників Землі. Висвітлено міжнародний аспект науково-організаційної діяльності Віталія Григоревського, його роботу в Комісії з багатостороннього наукового співробітництва між Академіями Наук соціалістичних країн. Відзначено діяльність Віталія Григоревського, як ініціатора та координатора кооперативних досліджень у галузі фотометричних спостережень штучних супутників Землі за програмою SPIN, учасниками якої були станції Народної Республіки Болгарії, Чехословацької Соціалістичної республіка, Угорської Народної Республіки, Німецької Демократичної Республіки, Польської Народної Республіки, Радянського Союзу і Об'єднаної Арабської Республіки (Єгипет). Висвітлено маловідомі факти з біографії вченого.*

***Ключові слова:*** *Одеська астрономічна обсерваторія; Кишинів; фотометричні спостереження; штучні супутники Землі; SPIN*

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## Жизнь и научная деятельность украинского астронома В. М. Григоревского (1930-1981)

***Аннотация.*** *В 2020 году научная общественность будет отмечать 90-летие со дня рождения Виталия Григоревского – украинского астронома, специалиста в области спутниковой астрономии, представителя научной школы выдающегося украинского ученого, члена-корреспондента Академии наук УССР, директора Одесской астрономической обсерватории, профессора Владимира Платоновича Цесевича. В статье на основании комплексного использования биографического метода и методов библиографического и источниковедческого анализа исследованы основные вехи жизни и научной деятельности Виталия Григоревского. Рассмотрены херсонский, одесский докишиневский, кишиневский и одесский послекишиневский периоды жизни ученого и его трудовая деятельность в Одесском и Кишиневском государственных университетах, Одесском технологическом институте им. М. В. Ломоносова. Определены основные направления научных изысканий ученого: физические процессы в полуправильных переменных звездах, фотометрические исследования искусственных спутников Земли, исследования*

*геометрии и движения искусственных спутников Земли и малых планет, оптимизация технологических процессов математическими методами с применением электронно-вычислительных методов. Показан вклад Виталия Григоревского в становление и развитие нового для 60-х годов прошлого века направления научных исследований – фотометрических наблюдений искусственных спутников Земли. Освещен международный аспект научно-организационной деятельности Виталия Григоревского, его работа в Комиссии по многостороннему научному сотрудничеству между Академиями наук социалистических стран. Отмечена деятельность Виталия Григоревского, как инициатора и координатора кооперативных исследований в области фотометрических наблюдений искусственных спутников Земли по программе SPIN, участниками которой были станции Народной Республики Болгарии, Чехословацкой Социалистической республики, Венгерской Народной Республики, Германской Демократической Республики, Польской Народной Республики, Советского Союза и Объединенной Арабской Республики (Египет). Освещены малоизвестные факты из биографии ученого.*

***Ключевые слова:*** *Одесская астрономическая обсерватория; Кишинев; фотометрические наблюдения; искусственные спутники Земли; SPIN*

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# The development of railway transport engineering in the Russian Empire in the second half of the nineteenth century

***Abstract.*** *The article is devoted to the consideration of the features on the development of railways and railway engineering in the second half of the XIX th century. It is well known that railway transport in European countries emerged in the eighteenth century, and the nineteenth century was a period of rapid development of raiway systems, railway technology and the creation of operation technologies. The author of the article shows that the development of railway transport engineering in the Russian Empire began in the 30s of the XIX century and went on at a rapid pace. It is clear that foreign technology was used at first, and foreign technology thought was significantly influenced by technology. As the whole policy of the tsarist government was aimed at reducing the country's dependence on potential opponents, the idea of forming a Corps of national transport engineers was greatly supported. Among its graduates were such well-known engineers as P. P. Melnykov, M. I. Lypyn, V. P. Sobolevskyi, M. A. Beleliubskyi, D. I. Zhuravskyi and others who managed to create a national scientific school in the field of railway transport. Almost all problems were solved independently without the help of foreign specialists. Among them, according to the author, the most significant were "Track bed structure", "The development of signalling systems, centralization and block signal system" and "The development of rolling stock". Based on the analysis of a large number of sources, the author concludes, that in the second half of the nineteenth century the development of industry in the Russian Empire went through capitalist reforms. Expansion of domestic and foreign markets, active domestic and foreign trade led to the need to develop means of communication. The railways proved to be the most powerful and economically effective. They connected different regions, places of production and consumption, facilitating, speeding up and reducing the cost of delivery of raw materials and goods. In the 60-80's of the XIX century there was a significant increase of the railway network. The construction was mainly carried out at the expense of private joint stock companies. During that period, foreign specialists who were not interested in the qualitative development of the Russian railway network played a major role in the construction and management of the*

*railway tracks. With the increasing demand for this new type of transportation, there was a need for technical modernization of the entire industry.*

***Keywords:*** *railway transport; engineering; track bed structure; railway bridges; railway engineering; scientific research*

## Introduction

The development of railway transport engineering in the Russian Empire began in the 30s of the XIX century and went on at a rapid pace. At first, a significant influence of foreign technical thought was felt in this direction, but later a national school of railway engineers was formed.This was largely due to the opening of the Institute of the Railway Engineers Corps. Among his graduates there were such famous engineers as P. P. Melnykov, M. I. Lypyn, V. P. Sobolevskyi, M. A. Beleliubskyi, D. I. Zhuravskyi and others who managed to create a national scientific school in the field of railway transport.

Due to their fruitful work, entire directionsof the national railway science were formed and successfully developed. Almost all problems were solved independently without the help of foreign experts.

**The purpose** of this article is to analyze the development of railway transport engineering in the Russian Empire in the second half of the XIX th century.

## Research methods

The methodological basis of the work comprises the scientific principles of research, such as objectivity, historicism, systemic, complexity. The principles of objectivity and that of historicism enable consideration of the studied historical events in their interrelation and development, giving the grounds to a comprehensive analysis and reliable assessment of historical facts. The application of the systemic method to the work allowed investigating comprehensively railway transport engineering in the Russian Empire in the second half of the nineteenth century (Pylypchuk & Strelko, 2016; Pylypchuk & Strelko, 2017; Pylypchuk & Strelko, 2019).

## Results and discussions

### *Track bed structure*

In the Russian Empire works on improving basic elements of the railway track were carried out in the first years of construction and operation of railways. A variety of topographical and climatic conditions made the builders use different constructive techniques in the construction of the roadbed.

The ballast layer on the railways of the Russian Empire was created from various materials. On the railway line Petersburg-Moscow, the prism of the ballast layer was two-layered (crushed stone and sand pad), and on many other railways – with sand and gravel materials. In the construction of railways in the southern regions of Ukraine, shell rock was used as a ballast layer. The thickness of the ballast under the sleepers was 30-40 cm. The desire to save some money forced railways to reduce this amount, which later led to numerous injuries of the main plane of the roadbed. In

this regard, in the late 90's of the nineteenth century, the thickness of the ballast layer was at least 55 cm.

In 1906, at the XXIV Congress of Railway Engineers it was decided to improve the ballast quality through the use of crushed stone and gravel. The outline of the main plane of the roadbed had a trapezoidal shape on single tracks, and a triangular one on double tracks, which provided a favorable environment for water drainage. The width of the main plane on single lines was from 4.7 to 7.6 m, on double-track lines – from 9.4 to 11.5 m. The slopes of the roadbed, depending on the soil, were taken as follows: 1:1, 2, 2:2. The roadbed in the transverse profile represented embankments and excavations. For surface water runoff, ditches with a longitudinal slope of at least two degrees were arranged (Kraskovskij & Uzdin, 1994).

Wooden railroad sleepers, as well as ballast prism, served as a rail track base for national railways. The application of wooden sleepers was due to their relatively low cost, simplicity of forms and advantages in operation. The dimensions of the cross section and the length of the sleepers were determined empirically. In the concession period of railway construction, the dimensions of sleepers were determined by the technical conditions that were produced for each line separately. The most common were flat sleepers, in some cases, rectangular sleepers were used. In 1886, the first circular was issued, establishing six sizes of sleepers. Mostly these were rectangular sleepers; flat sleepers were allowed to produce only from the oak. As joints it was recommended to use only square-edged from four sides rectangular sleepers.

Three years later, a new circular was issued. It added to the previously established types of sleepers six more, trimmed only on two edges, including joint sleepers. In 1900, the Ministry of Railways trying to put things in the sleepers economy in order, allowed the use of five more types of flat and rectangular sleepers.

Wooden sleepers rot, so it became necessary to impregnate wood with various antiseptics - resin, and later with creosote oil, zinc chloride, etc. For this purpose, treating plants were built in Mykolaivska, Moscowsko-Nizhnohorodska, Orlovsko-Vitebska, Katerynynska, Kursko-Kharkivska-Azovska, and other railways. Sleepers treating allowed increasing their life term from four to eight years. To reduce sleepers cracking some railways tied them with various kinds of brackets, or used sleepers' reinforcement with metal parts (Pershyn, 1978). The rail is one of the most important elements of the permanent way. In the first years of railway operation the rails were iron, weighing 24-35.5 kg/m, with a joint on the sleepers. Their length was from 4.6 to 6.1 m. Iron rails quickly wore out.

Therefore, they soon turned to more economical double-layer rails: the upper part of the head was made of steel, the web and the bottomwere iron.For the first time steel rails appeared in 1868. Since 1875 they have become widespread. In the late 90's of the nineteenth century steel rails were laid down on all mainlines.

The rail joints were originally arranged on sleepers, the ends of the rails were combined with a covering cast-iron rail-chair that was fastened to the sleepers. In 1858, rail-chairs were abandoned and switched to the joint on the tie, but with base plates and strap bars, and since1868 they have begun to use suspended joints.

With this type of joint, strap bars were first used, and then splice-bars (angular fishplates). At first they were placed on the outside of the joint, and since 1883 they have began to move on joints with splice-bars on both sides of the rail.

In the Russian Empire, earlier than in other states, the practice came to the necessity of creating unified rails for the whole country. In 1874 the Ministry of Railways adopted three types of iron and four types of steel rails. The main feature of the type was the linear weight of 1 foot (30.5 cm) of the rail. In 1903, four types of rails were introduced to organize the rail economy – I, II, III, IV. A major step forward in the unification of rails was the approval in 1908, the four common types of rails under the index "a" (Ia, IIa, IIIaa, IVa), they had been a standard until 1947. The heaviest was the rail Ia, which weighed 43.6 kg/m, and the lightest was IVa – 30.9 kg / m. The rails were made in length 10.68 m. Such rails existed on the railways of the Russian Empire for four decades and withstood a six-diameter magnification in carrying load (Zapysky RTO, 1867, p. 51). In 1903 the Ministry of Railways issued a circular which established the maximum axle load of the rolling stock, depending on the type of permanent way. In 1914, the circular was supplemented by Interim guidelines, which, in turn, regulated the ratio of the most acceptable speeds of the trains and the type of the permanent way. Thus first additional speed limit was introduced in small radius curves. As we see, during this period, work on typing the permanent way of the track depending on the conditions of its operation was done (Zhurnal Obshcheho sobranyia chlenov-uchredytelei KO RTO po sveklosakharnoi promyshlennosty ot 8 yanvaria 1871 h.).

With the development of railways consistently improved and qualitatively changed a very important element of the track structure, allowing moving the rolling stock from one track to another – railroad switch. It consisted of switches and toes. First, switches with movable rails were used, then switches with point rails and switch points appeared. At the same time point rails were located on continuous metal switch slide plates. The first toes were movable, consisted of short rails, later fixed cast toes began to use instead of them. Later they began using prefabricated toes from conventional rails with steel cast tongue pieces. On most railways, two types of switches were used: the first one was longer and the toe brand 1/11, the second of the smaller length and with the toe brand 1/9.

Since 1886, the railways began to lay down bent switch blades, which were produced from Williams' rails. English lap switches were widespread. This made it possible to reduce significantly the length of the switch lead.

Structurally the toes were of three types: continuous cast, prefabricated from Williams rails, and prefabricated cast tongue pieces of Camlim system (Kraskovskyi & Uzdyn, 1994, p. 213).

*The development of signalling systems, centralization and block signal system*

For the first time, signals on the railroad were introduced by J. Stephenson at the Manchester-Liverpool Railroad in 1834. He suggested placing signalmen at a certain distance that could to give signs to the engine driver. The first signals were points that could be rotated, at night the signals were given using lanterns. In 1841,

Englishman Gregory designed a semaphore. Just then the transition from the movement of trains with time-interval system to the space-interval system became possible. Means of communication were the telegraph and later telephone.

In Russia, the engineers Jacobi and Shilling worked on the problem of an optical telegraph (semaphore). In 1849, the famous inventor Werner Siemens was invited to Russia, who took part in the installation of the first telegraph on the St. Petersburg-Moscow railway. From the 50s of the nineteenth century Siemens systems began to be spread on all national railroads (Vyrhynskyi, 1938, p. 205).

A major step forward in ensuring the safety of train movement was the introduction of a block signal system, with which the track semaphores closed for a while, until the the train was on the relevant section of the track. The main rule of the railway safety emphasized that there might be only one train on the crossing. Previously, the next train was let out for a crossing only when the time required for the previous train to pass was over. However, this system was not reliable, because it was not possible to make sure that the previous train has already passed over the crossing. Therefore, in 1844 the English engineer Cook proposed the principle of blocking the track, better known as a block system. Its essence was that the track between the stations was divided into small sections. The train could occupy a crossing or a section of the track between the stations only if the previous train had already fired this crossing. Thus, the space-interval system and not time-interval system was maintained between two trains. In order to notify that the crossing was free special devices were used. This innovation became widespread after the invention of devices for block systems in 1859 by a French engineer Thayer. They were first used in France on the Paris-Saint-Germain railway. A turning disk served as a block signal which was connected with the moving tire to the running rail with the help of the arms and levers.

When passing the train flanges of the wheels pulled the tire from the rail. This caused the disc to be closed. At the same time, the piston installed in the mercury brake disc raised, which kept the disk in the closed position. After a certain time (about 6 minutes) after the passage of the train, the piston, overcoming the viscosity of mercury, returned to its place, and the disk was closed.

After the invention of the Tayer machine, the first attempts were made to apply automatic blocking of sections by the steam locomotive by means of electric current. For this it was proposed to place special pedals along the track at the points of section division. Arriving to the section the train automatically informed block post that the section was busy. Clearing the line, the train pressed another pedal, giving signal on the empty track. In 1867 William Robinson suggested using running rails as conductors of electric current and created a special design of the wayside signaling system. In 1869, he developed the first model of electric automatic block signaling, which was demonstrated at an exhibition in New York.

In 1872, engineer Lathrih improved blocking devices by proposing electrical semaphores. The principle of their operation was in the fact that the value of the signal was dependent on the position of electrical devices that were at the shunting

towers. Later, electrical systems of Siemens, Reno, Shaperon, and others appeared (Stolpovskyi, 1891, p. 249).

In the late 80's of the nineteenth century English engineer Webb-Thomson invented traffic wands for regulating trains movements of on single-track lines. Since 1897 they have spread on the railways of the Russian Empire. In the 80s of the nineteenth century, the first national installations of mechanical centralization appeared. One of the most common was the system of mutual point and signals locking of professor Ya. M. Hordienko, first applied in 1885, first with rigid connecting-rod, and later with flexible. Y.M. Hordienko's invention was awarded a prize at the All-Russian Exhibition in Nizhnyi Novhorod in 1896 and at the World Exhibition in Paris in 1900.On the South-Western railways, the Sikes interlocking system systems with rugged drive, the wired of Siemens and Halske, the hydraulic of Bianki and Servantes, and the electric of Siemens and Halske were common.

*The development of rolling stock*

The first commercialize locomotives for national railways were imported from England and Belgium. The design of these locomotives was of the same type: in the general rigid frame they had one driving wheel set of large diameter (within 1700-1900 mm), pilot wheel sets and supporting, as well as wheel sets of smaller diameter. Complete evaporation boiler heating surface was 50-60 $m^2$, the vapor pressure reached 6-7 bar, capacity 70-75 hp, the maximum speed reached 60 km/h. Steam locomotives were named "Strila", "Bohatyr", "Orel", "Lev" and "Slon".

Subsequently, steam locomotives began to be assembled in Russia, at the Oleksandrivskyi plant in St. Petersburg, since 1844. By the time the plant had unique equipment. Steam hammers, a lathe for pulling pipes, a gear cutting machine, a special installation for testing metal structures, as well as mechanical and hydraulic presses were installed in the workshops. Thanks to these technical capabilities, the Oleksandrivskyi plant became advanced in locomotive engineering. Since 1850, in addition to the construction of new ones, the plant has started to repair old cars and manufactured spare parts for them. In 1846 the first cargo steam locomotive was produced. In addition to cargo steam locomotives, during 1848-1850 years 43 passenger locomotives were built. In general the Oleksandrivskyi plant had produced 164 steam locomotives by 1851.

Further growth of the railway network required the development of locomotive building. So, in 1869 Kolomenskyi and Kamsko-Votkinskyi plants began to build steam locomotives, and since 1870 Maltsevski plants and plants in St. Pereburg. Since 1892 the locomotive building began at the Briansk plant, in 1894 at the Putilov plant, and since 1898 at the Sormov plant. These enterprises formed the basis of locomotive development in the late XIX and early XX century.

For the first time on the territory of Ukraine, locomotives began to be built at Kharkiv (1897) and Luhansk (1898) locomotive works. The Mykolaivsk shipbuilding plant was partly engaged in the production of steam locomotives. New locomotives were also built at railroad workshops in Kyiv and Odessa. By repairing the rolling

stock and studying operational deficiencies, the workshops created the design of locomotives and cars, which by operational qualities could serve as models for specialized plants.

The rates of locomotive building development can be traced from the following data: in 1846-1868 in Russia 227 locomotives were built, and in the period from 1875-1880 – 1439 locomotives were built. It was approximately 239 locomotives per year. The construction of wagons also grew. In the period from 1875 to 1880 39280 freight wagons and 1005 passenger cars were built (Kraskovskij & Uzdin, 1994, p. 25).

The first locomotive built at the Oleksandrivskyi mechanical plant of the Petersburg-Moscow railway was a passenger locomotive of type 2-2-0 (the number of uncoupled wheel pairs, the number of driving wheel pairs and the number of trailing idle wheel pairs), later this type of locomotive received the designation of the "B" series. It had two spooked wheels, cast iron, without counterweights, driving wheel pairs with a diameter of 1705 mm, of which driving was the first pair. The internal eccentric steam distribution mechanism set in motion double (expansion) spools, which allowed reversing the machine and changing the degree of filling the cylinders with steam. This design was a significant step forward compared with those used on steam locomotives of the Tsarskoye Selo railway. Taking into account the flat profile of the St. Petersburg-Moscow railway such locomotives could drive six wagons trains at a speed of 40 km/h. Furthermore, the plant built locomotives with wheel arrangement 1-2-0 and 1-2-1.

The first locomotives were without booths and platforms; the locomotive crew was under the open sky. Blow-off valves opened from the outside when the locomotive was started. The freight train developed a speed of up to 22 km/h, and a passenger train up to 30 km / h. But at first, the locomotives were not divided into freight and passenger. In the future, these locomotives were upgraded by installing booths, platforms, spur gears, injectors, and buffers.

Improvements for weather protection of the locomotive brigade began to appear from about 1865. At first these were metal sheets for protection against headwind, than umbrellas, and finally closed booths, which was especially important in the conditions of the northern climate. At the same time, instead of hand pumps, simple and compact devices − injectors − began to be set up to supply water to the boiler.

In 1868-1870 the first technical specifications were made, providing for the stipulation the type of work of the engine being designed: its type, the number of axles in the tender, the most allowable pressure on the rail from the wheel band. Locomotives began to divide into passenger, freight and shunting. The greatest pressure from the wheel bands of one wheel set on the rail was allowed up to 10 tons and in the 70s up to 21.6 tons. The capacity of freight trains of type 0-3-0 and passenger type 1-2-0 was 300-440 hp, the weight in working condition − 32-37 tons. The design speed of freight locomotives was 40-45 km/h. and passengers − up to 80 km/h.

The boilers of locomotives were built horizontally cylindrical, with a diameter of 1200-1400 mm, riveted from sheet steel, with 160-180 smoke tubes, mainly brass, flat-section fireboxes, made of red copper. The total heating surface was 85-133 $m^2$, the area of the firebox grate was 1.27-1.58 $m^2$. The boiler was provided with two injectors. Maximum steam pressure in the boilers was 8-10 at. The two-cylinder steam engine of single-stage expansion was installed on the engine frame. On each side on the outer side of the frame there was one cast-iron cylinder with a diameter of 394-460 mm, the piston stroke length was 553-620 mm. The valves were flat of box members with internal steam distribution. The diameter of the wheels of freight trains was 120-1418 mm. The diameter of the passenger trains wheels was 1520-1728 mm, bolster springs. The locomotives were provided with trailers for fuel and water. In 60-90, the XIX century plants built freight locomotives mainly of triaxial - type 0-3-0 or 0-4-0. Passenger locomotives were built according to type 1-2-0 or 2-2-0 (Artobolevskyi & Blahonravov, 1975 , p. 27).

At the end of the XIX century on domestic steam locomotives evaporative heating surfaces of boilers reached 150-160 $m^2$. The heating surface of the furnace reached to 11 $m^2$. and the firebox grate area up to 2.2 $m^2$. To reduce steam condensation, the insulation of the boiler and piping has improved. In order to reduce heat loss in the steam engine the principle of double steam expansion (compound) was used. In 1850, English engine driver John Nichols proposed a draft of a locomotive system compound James Samuel. In 1852, the system of D. Nichols was applied to freight and passenger locomotives, the results of the application were quite satisfactory. The locomotives of the compound Samuel system were equipped with two cylinders, having a ratio to the piston area of one to two. From a small cylinder, the steam was blown off to the large by means of a special valve. At a certain point in the stroke of the piston, steam passed from a small cylinder to a large one, and expansion took place in both cylinders simultaneously. It should be noted that steam was turned on into the large cylinder from the side of the piston working part of the small cylinder, and not from the side of the non-working part.

In England, the most authoritative supporters of the compound system were the chief engineer of the rolling stock of the London-North-West Webb Railway (Webb) and the chief engineer of the rolling stock of the North-Eastern Railway (Worsell). In 1878, by way of experiment Webb remade one of the old steam locomotives in the compound of Mallet system. This locomotive has worked 5 years. The results have been so satisfactory that Webb decided to introduce this system in widespread use. For this purpose in 1881 he constructed a new compound locomotive in his workshop. It had two outer high-pressure cylinders with a diameter of 11.5 inches and a low pressure inner cylinder diameter of 26 inches. The diameter of the driving wheels was 6.5 ft and the steam distribution of the Joey system. The high-pressure cylinders operated on the rear wheels, and the low-pressure cylinder on the driving wheels. The driving and rear wheels were not coupled with each other. Due to this, there was no need for coupling rods, and the locomotive had the same freewheeling as a locomotive with one pair of driving wheels, but having the same coupling on the

wheels with rails as that of a locomotive with coupled wheels. Designing this system, Webb tried to achieve the following results:

1. Development of a large locomotive power.
2. Savings in fuel consumption.
3. Utilization of all steam force.
4. More even distribution of forces affecting on the parts of the mechanism.
5. The same freewheeling, as in locomotives with one driving axle, but with the same coupling of wheels with rails, as in locomotives with coupled axle. New steam train went into operation on April 3, 1882 another 29 locomotives of the same type were built later (Stolpovskyi, 1891, p. 219). In Russia, the steam engines of the compound system began to be used on the initiative of O. P. Borodin. The first six such steam locomotives of the type 2-2-0 PB series were built in 1885 by Odessa workshops for the South-Western railways. In 1868, the Vladykavkaz Railway designed a six-axial 1-4-0 type steam locomotive with a boiler equipped with a powerful two-cylinder compound machine. These locomotives could drive large-weight trains, and the pressure on the rail was maintained up to 13 tons. Later, locomotives of this type were built at the Briansk and Kharkiv plants and received a series of"C". The use of such locomotives gave up to 15% fuel economy. By the end of the 1890s, about 13% of the locomotives were compound machines mainly in the two-cylinder version.

In 1905, the Kharkiv plant designed a compound-locomotive of type 1-4-0 of the "Sch" series. During the period of the greatest distribution of compound steam locomotives (1906-1909), the Kolomna and Luhansk plants built locomotives not only for native, but also for foreign railways.

Compound-machines were used in passenger steam locomotion. Among them are steam locomotives of type 1-3-0, designed by engineers of the Nikolaiev railroad and the Aleksandrovskyi plant and produced by the $N^d$ series in 1892. The diameter of the driving wheels of a locomotive was 1900 mm, the pressure on the rail was up to 15 tons. The vapor pressure was up to 12 at. With minor design changes, these locomotives were built in other factories under the series of $V^s$, $N^v$, well, and $N^p$. They ran on wood, coal and oil at the beginning of the First World War.

The increase of the passenger trains speeds required more steam-producing boilers of steam locomotives, with a steam pressure of 11-12 at, and a further increase in the diameter of running wheels. Such requirements are related to the fact that the "Rules of technical operation of railways" limited the number of turnings of the driving wheels: for passenger locomotives – up to 260 r/min, for freight locomotives up to 225 r/min. High speeds of trains were used on some railways, so there was a need to build high-speed locomotives with large moving wheels (up to 2000 mm in diameter for passenger and 1300 mm for freight), although this reduced the traction force of locomotives to some extent. By reason of the necessity to improve traffic safety in 1891, the "Rules for the Design, installation, maintenance and inspection of steam boilers" were enacted, and the "Rules for testing action of velocimeter" were introduced. According to the circular of the Ministry of Railways

on the frontal part of high-speed trains' locomotives, it was supposed to put fanlights on with a silver-plated or nickel-plated reflector.

Constant contradictions between the requirements of the growth of traction and the limitation of loads from moving wheels on the rails forced the designers to look for new solutions. One of them was the combining of several wheels with a thrust (driving rod). By the end of the XIX century passenger locomotives had up to three coupling axles, and freight - up to four; the load from the wheel set on the rails was 13 tons.

In 1902, on the initiative of Ye. Ye. Noltein, the Kolomna Plant equipped the first locomotive in the country with a superheated element (series Zh of type 2-3-0). With the start of use of superheated steam, which provided savings of up to 25% of fuel and about 35% of water, round piston throttle that reliably maintained the temperature of saturated steam at 300 - 350 degrees Celsius became widespread. The increase in the size and weight of the boilers, which accounted for the majority of the total weight of the locomotives, led to an increase in loads on the rails, which were limited by norms. In this regard, coupling wheel sets, the number of which reached five were introduced additionally. However, placing them in one rigid frame made it difficult to fit locomotives into curved sections of the track. To solve this problem, engineers and designers of steam locomotives went for some complications of the crew part: the introduction of flangeless wheels, acceleration of axles in axle boxes, axle boxes in the frame, and thrust bearings on the axial pins. Also, there appeared designs of duplex locomotives with two steam engines. The heating surface of the boilers was 200 $m^2$; the vapor pressure was 12-13 atm. The use of superheated steam contributed to the operation economy of the machines. The diameter of the wheels of locomotives with the aim of increasing the traction force was set in the optimal dimensions: passengers 1830-1920 mm, freight − up to 1320 mm. Passenger locomotives had a design speed of 115-130 km/h, and freight up to 70 km/h. The load from the movable wheel sets on the rails was 16-17 tons. Capacity at the calculated boost of the boiler overload operation and the machine reached 1500 h.p. From January 1913, in order to identify locomotives, a single series system was introduced for the entire railway network. Prior to that, railways ordering steam locomotives at the plants, independently assigned series in an arbitrary manner, as a result of which, on different railways, locomotives had the same types of series, but different in characteristics and wheel arrangement (Artobolevskyi & Blahonravov, 1975 , p. 30).

In 1913, the Russian Empire's locomotive fleet was 18695 locomotives (on all private and state railways combined), including 3550 passenger ones. Out of the total number of locomotives, 54% were built in 1900-1913. On average, there were 32 locomotives per 100 kilometers of the network, while private railways, which accounted for approximately 30% of the total network, had 1.5 times less steam locomotives. The average daily mileage was about 112 km. 67% of the total number of steam locomotives operated on coal, spending 7200000 tons a year. 26% used oil and fuel oil (1.8 million tons), some were heated with firewood (5.2 million cubic meters). In general, some series of domestic steam locomotives were at the level of

the best examples of world steam locomotive in terms of workmanship and design. This was facilitated by scientific developments, theoretical and experimental studies performed by members of the Mechanics and Construction Department of the Kyiv branch of the Russian Technical Society, O. P. Borodin, L. M. Levi, Ya. V. Shotlander and other specialists in the field of steam locomotive engineering, who gained recognition both in Russia and abroad. During the First World War, the production of locomotives fell sharply; a significant part of the locomotive fleet was disabled, which caused great difficulties in organizing the movement of trains. (Isaienko, 2016, p. 35).

In general, steam locomotion in the Russian Empire has undergone four successive stages in its development. The first stage was from 1834, from the locomotive of the Cherepanovs, to the 60-ies of the XIX century. The need for locomotives of a small number of railway tracks (their total length in 1860 was about 1700 km) was mainly provided by two small factories. The second stage − from 1860 to 1870 − coincided with a significant increase in railway construction. The third stage − from 1870 to 1900 − is characterized by the significant development of Russian steam locomotive building, its formation as an independent industry branch. The fourth stage − from 1901 to 1917 − is associated with significant progress in increasing the capacity of the newly built steam locomotives and the development of scientific foundations of their design and operation (Stolpovskyi, 1891, p. 219).

**In view of the above, we can conclude** that in the second half of the nineteenth century the development of industry in the Russian Empire went through capitalist reforms. Expansion of domestic and foreign markets, active domestic and foreign trade led to the need to develop means of communication. The railways proved to be the most powerful and economically effective. They connected different regions, places of production and consumption, facilitating, speeding up and reducing the cost of delivery of raw materials and goods. In the 60-80's of the XIX century there was a significant increase of the railway network.Theconstruction was mainly carried out at the expense of private joint stock companies. During that period, foreign specialists who were not interested in the qualitative development of the Russian railway network played a major role in the construction and management of the railway tracks. With the increasing demand for this new type of transportation, there was a need for technical modernization of the entire industry.

Since the 30-ies of the XIX $^{th}$ century the process on creating a national railway with the entire infrastructure started: the formation of a carriage and rolling stock fleet, the development of a track network, the organizational formation of the industry as an economic unit. This process was associated with scientific researches' development in all these areas.

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## Розвиток техніки залізничного транспорту в Російській імперії у другій половині XIX ст.

***Анотація.*** *Стаття присвячена розгляду особливостей розвитку залізниць та залізничного обладнання у другій половині XIX століття. Добре відомо, що залізничний транспорт у європейських країнах виник у XVIII ст., а XIX століття було періодом швидкого розвитку залізничних систем, залізничної технології та створення експлуатаційних технологій. Автор статті показує, що розвиток техніки залізничного транспорту в Російській імперії розпочався в 30-х роках XIX століття і проходив швидкими темпами. Зрозуміло, що спочатку використовувались іноземні технології, і іноземна технічна думка суттєво впливала на технологію. Оскільки вся політика царського уряду була спрямована на зменшення залежності країни від потенційних опонентів, ідея утворення Інституту корпусу інженерів шляхів сполучення отримала велику підтримку. Серед його випускників були такі відомі інженери, як П. П. Мельников, М. І. Липин, В. П. Соболевський, М. А. Белелюбський, Д. І. Журавський та інші, яким вдалося створити національну наукову школу у галузі залізничного транспорту. Майже всі проблеми вирішувались самостійно без допомоги іноземних фахівців. Серед них, на думку автора, найбільш значущими були «Верхня будова колії», «Розвиток систем сигналізації, централізації та блокування» та «Розвиток рухомого складу». На основі аналізу великої кількості джерел автор робить висновок про те, що у другій половині XIX століття розвиток промисловості в Російській імперії пройшов шляхом капіталістичних реформ. Розширення внутрішнього та зовнішнього ринків, активна внутрішня та зовнішня торгівля спричинили необхідність розвитку засобів зв'язку. Залізниці виявилися найбільш потужними та економічно ефективними. Вони з'єднували різні регіони, місця виробництва та споживання, полегшуючи, прискорюючи та скорочуючи витрати на доставку сировини та товарів. У 60-80-х роках XIX століття відбулося значне зростання залізничної мережі. Будівництво в основному велося за рахунок приватних акціонерних товариств. У цей період велику роль у будівництві та управлінні залізничними коліями відігравали іноземні спеціалісти, які не були зацікавлені у якісному розвитку російської залізничної мережі. Зі збільшенням попиту на цей новий вид транспорту виникла потреба в технічній модернізації всієї галузі.*

***Ключові слова:*** *залізничний транспорт; верхня будова колії; земляне полотно; залізничні мости; залізнична техніка; наукові дослідження*

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## Развитие техники железнодорожного транспорта в Российской империи во второй половине XIX в.

***Аннотация.*** *Статья посвящена рассмотрению особенностей развития железных дорог и железнодорожного оборудования во второй половине XIX века. Хорошо известно, что железнодорожный транспорт в европейских странах возник в XVIII в., а XIX век было периодом быстрого развития железнодорожных систем, железнодорожной технологии и создания эксплуатационных технологий. Автор статьи показывает, что развитие техники железнодорожного транспорта в Российской империи начался в 30-х годах XIX века и проходил быстрыми темпами. Понятно, что сначала использовались иностранные технологии, и иностранная техническая мысль существенно влияла на технологию. Поскольку вся политика царского правительства была направлена на уменьшение зависимости страны от потенциальных оппонентов, идея создания Института корпуса инженеров путей сообщения получила большую поддержку. Среди его выпускников были такие известные инженеры, как П. П. Мельников, Н. И. Липин, В. П. Соболевский, М. А. Белелюбский, Д. И. Журавский и другие, которым удалось создать национальную научную школу в области железнодорожного транспорта. Почти все проблемы решались самостоятельно без помощи иностранных специалистов. Среди них, по мнению автора, наиболее значимыми были «Верхнее строение пути», «Развитие систем сигнализации, централизации и блокировки» и «Развитие подвижного состава». На основе анализа большого количества источников автор делает вывод о том, что во второй половине XIX века развитие промышленности в Российской империи прошло путем капиталистических реформ. Расширение внутреннего и внешнего рынков, активная внутренняя и внешняя торговля вызвали необходимость развития средств связи. Железные дороги оказались наиболее мощными и экономически эффективными. Они соединяли разные регионы, места производства и потребления, облегчая, ускоряя и сокращая расходы на доставку сырья и товаров. В 60-80-х годах XIX века произошел значительный рост сети железных дорог. Строительство в основном велось за счет частных акционерных обществ. В этот период большую роль в строительстве и управлении железнодорожными путями играли иностранные специалисты, которые не были заинтересованы в качественном развитии российской*

*железнодорожной сети. С увеличением спроса на этот новый вид транспорта возникла необходимость в технической модернизации всей отрясли.*

***Ключевые слова:*** *железнодорожный транспорт; верхнее строение пути; земляное полотно; железнодорожные мосты; железнодорожная техника; научные исследования*

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# The contribution of Academician I. H. Aleksandrov to the development of national hydraulic engineering (on the example of scientific and engineering approaches to irrigation problems in the Turkestan region)

***Abstract.*** *History of science and technologies as a branch of scientific knowledge is aimed at studying the most significant ideas of prominent scientists and practitioners and their influence on the world science development and the technologies' advancing. In the opinion of the authors of the article, one of such figures of the early twentieth century is Academician I. H. Aleksandrov. Historical and scientific analysis of life and activity of I. H. Aleksandrov as a scientific theoretician, engineer, a science organizer is of high topicality due to the scale and versatility of his scientific contribution. Scientific creative work of I. H. Aleksandrov can be divided into five main directions of development of science and technologies: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation. In the context of the development of hydraulic engineering and hydropower, I. H. Aleksandrov had world-class achievements that glorified national science. But till recent years I. H. Aleksandrov is mostly recognized as the designer and one of the constructors of the Dnipro hydroelectric power station near Zaporizhzhia (1927-1932) (he prepared a project and directed the construction of the largest hydroelectric power station in Europe at that time) or as a creator and developer of the methodology for economic zoning of the Soviet Union. Other achievements and ideas of Academician I. H. Aleksandrov are rarely mentioned in the scientific papers and researches. The article concludes that the breadth of scientific and technical interests of I. H. Aleksandrov was the result both of his individual abilities and of the thorough theoretical and practical training received by a young engineer I. H. Aleksandrov from the highly qualified teaching staff of the Moscow Higher Technical School and the Moscow Engineering School of the Office*

*of the Ways of Communications. I. H. Aleksandrov's gigantic working capability played an important role in his life as well. Great number of sources showed that occupying different positions, I. H. Aleksandrov participated in solving complex technical issues of contemporary epoch, and his scientific interests had always been in the context of the tasks of the engineering and science of his time. I. H. Aleksandrov initiated scientific discussions on the construction of ports and canals, in his work he contributed in every way to the development of home industry in general, and to hydraulic engineering in particular. The authors assert that the modern view on the scientific heritage of I. H. Aleksandrov in the context of the development of hydraulic engineering, hydropower and rail transport unambiguously acknowledges that in a concentrated-generalized form ideas, theories and concepts, put forward and scientifically grounded by Academician I. H. Aleksandrov almost a hundred years ago, even today contribute to the development of scientific and technological process.*

***Keywords:*** *I. H. Aleksandrov; hydraulic engineering; irrigation projects; energy supply projects; river flow regulation*

## Introduction

Ivan Havrylovych Aleksandrov (1875-1936) is considered to be one of the most prominent hydropower engineers and hydro-technicians of the soviet period. As it is known, I. H. Aleksandrov is the founder of the complex designs of large hydroelectric stations and irrigation systems in the USSR. Ideas by I. H. Aleksandrov significantly influenced the development of both soviet and world hydropower scientific concepts and approaches. Furthermore, the original ideas of the scientist were innovative at the level of world achievements of the corresponding period technology. I. H. Aleksandrov's contribution to solving the problems of irrigation of the lands of Central Asia is surely to be considered a striking example of his engineering creativity in the early twentieth century (Zenzinov & Ryzhak, 1978). Historical and scientific analysis of the life and activity of I. H. Aleksandrov as a scientist, engineer, organizer of science and technology is relevant in view of the scale and versatility of his scientific contribution. In the context of the development of hydraulic and hydropower engineering, the development of transport communications, I. H. Aleksandrov had the achievements of the world level, which glorified the national science.

O. Isaienko, in his investigation of the life path, scientific contribution, and organizational and educational activity of academician Ivan Havrylovych Aleksandrov, substantiates that scientific researches by I. H. Aleksandrov were carried out in the context of the challenges of the engineering science of his time (Isaienko O. & Isaienko S., 2016). Scientific and creative contribution by I. H. Aleksandrov can be divided, according to O. Isaienko, into five main directions of science and technology development: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation (Isaienko, 2018).

Our analysis of a large selection of historical and literary sources of the second half of the nineteenth – early twentieth centuries about the life and activities of a prominent engineer and scientist showed that although the breadth of scientific and technical interests of I. H. Aleksandrov and the versatility of his gift impressed contemporaries and successors, today there is a lack of scientific publications, which would consider the activity and development of scientific views of Academician I. H. Aleksandrov in the context of development of hydraulic engineering and hydropower in our country.

This paper's purpose is to highlight the development of I. H. Aleksandrov's scientific views, as well as to evaluate scientific and engineering contribution of the Academician to the development of national hydraulic engineering.

**Research methods**

The methodological basis of the work comprises the scientific principles of research, such as objectivity, historicism, systemic, complexity. The principles of objectivity and that of historicism enable consideration of the studied historical events in their interrelation and development, giving the grounds to a comprehensive analysis and reliable assessment of historical facts (Pylypchuk & Strelko, 2016; Pylypchuk & Strelko, 2017; Pylypchuk & Strelko, 2019). The application of the systemic principle to the work allowed investigating more comprehensively the achievements of I. H. Aleksandrov in the field of hydraulic engineering development.

**Results and discussions**

In 1912 I. H. Aleksandrov was invited to work at the Land Resources Department of the Ministry of Agriculture of the Russian Empire. He readily accepted the proposal, since the latter was fully in line with his plans to devote himself to solving the problems of hydro-engineering and, above all, to the problems of using "white coal", that is, hydropower.

However, initially during a year Ivan Havrylovych was not concerned with hydro-engineering and hydropower, but was designing concrete bridges over irrigation channels in the Holodnyi Steppe (Turkestan). His designs of bridge spans of various types were quickly implemented. Therefore, Ivan Havrylovych was appointed the head of the exploration works in the Syr Darya basin, which were carried out in connection with the planned construction of irrigation reservoirs at the top of the river.

Appointment of a talented engineer to be the head of the exploring parties in Turkestan seemed strange to many. Even some colleagues and friends of Ivan Havrylovych were unclear as to why the Ministry of Agriculture needed to send a gifted engineer from St. Petersburg to the largest "shackle" of the empire – into the Syr Darya river basin. However, such a "business trip" is easy to explain. In the years leading up to the First World War, the interest of the government and private capital to the problems of irrigation of the fertile lands of Central Asia increased sharply. The government, in turn, believed that the irrigation of Turkestan was a crucial

condition for enhancing colonialist activity in this troubled land. Only by moistening the local lands one could expect to relocate to this royal colony some part of the Russian peasantry, which was intended to become the pillar of colonial policy of the Russian Empire, the defender of the interests of autocracy and Russian capitalism in Turkestan. The interest of private businesses could also be explained simply. It was a sober and far-sighted calculation of huge profits at the expense of the harsh colonial exploitation of the local population, which was involved mainly in the cultivation of valuable raw materials – cotton and other southern industrial and fruit crops. Existing irrigation facilities were supported only by the hard and time-consuming work of the population for whom water was synonymous with life. They could not be effectively used to meet the new challenges posed by the tsarist government and private capital.

The development of irrigation in the Turkestan region required, along with large allocations, the participation of first-class engineers and specialists (Hurinchuk, 2012). The last circumstance also explains the choice of the Ministry of Agriculture to nominate Professor I. H. Aleksandrov, a well-known St. Petersburg engineer, the best suited for conducting large-scale studies that were of paramount importance for the irrigation of the vast expanses of Central Asia.

Ivan Havrylovych leaves St. Petersburg, leaves a young family in a small apartment on Vereyska Street and travels to distant and almost unknown Turkestan, where he is awaited by new vivid impressions and his favourite practical work. Here Aleksandrov, for the first time, demonstrates himself as a talented researcher and irrigator in the management of research at the Syr Darya Basin. The exploration works in Central Asia were conducted by I. H. Aleksandrov in the summer, after which in September-October, he and his assistants returned to St. Petersburg. There, for several months, engineers carried out the cameral processing of materials obtained in the expedition.

As a highly educated person of his time, I. H. Aleksandrov stressed that irrigation in Central Asia, as in other countries in the East, had existed for thousands of years. In ancient times (BC), it was already well developed, but later due to a number of wars and adverse political and economic conditions, irrigation in the eastern countries degraded. In the early twentieth century Turkestan's irrigation was in a state of decline. The irrigation network was limited and its technical level was very low (in general, irrigation techniques remained the same as in the old days). In addition, within the feudal organization of economic life, irrigation systems and structures were in the hands of the ruling classes not wishing to invest in upgrading it or at least in developing the system.

One of the most developed in the irrigation terms in Turkestan, the Fergana Region – the "pearl of Central Asia" as it was sometimes called at those times – is located in the Syr Darya Basin, yet in the pre-revolutionary period (until 1917-1924) it had nevertheless hundreds of thousands of hectares of non-irrigated land. These undeveloped lands under proper irrigation could give the most valuable crops: cotton, grain, fruits, grapes etc. However, the local and foreign capital as well as the tsarist government spent only a pitiable sum on the irrigation of the lands. During the period

from 1883 to 1917 the cost of capital irrigation works in some part of the territory of the former Turkestan amounted to only 36.4 million rubles. These costs were sufficient to complete the irrigation works of only 80000 hectares of old and new lands (Shamsutdynov, 1949, p. 14). With great difficulties, progressive domestic hydro-technicians sought scarce funds for research and exploration aimed at improving the irrigation of Central Asia. After all, this was a vital condition for the development of the region's richest agricultural resources and the fight against the terrible impoverishment of the local peasantry.

The exploration works in the Syr Darya Basin over several years (until 1917) provided material for the development of a project for irrigating half a million hectares of land in south-eastern Fergana. This project was "implemented" by I. H. Aleksandrov in 1918. The project covered large tracts of irrigated land in Skobeliev, Kokand, Osh and Andijan regions. It should be noted that these lands on the left shores of Syr Darya and Kara Darya, had previously attracted the attention of private entrepreneurs. In 1910 and 1912, attempts were made to obtain concessions from the tsarist government for their irrigation. The project of irrigation of these lands, proposed by private entrepreneurs, involved the construction of a dam on the Naryn river, the principal structure of the main canal crossing the Kara Darya aqueduct (approximately along the Andijan river meridian) and running parallel to the Central Asian railway line up to the river Kokand. This channel was expected to irrigate more than 200,000 ha of desert land.

Having thoughtfully studied the previously developed plan, Ivan Havrylovych proposed a completely different project, which was fundamentally different from the previous one in that water was used not from the Naryn river but from the Kara Darya and smaller mountain rivers that flowed from the Altai Ridge: the Ak-Bura river, the Soh, the Shakhimardan and others. The Kara Darya river is a large tributary of the Syr Darya. Developing a project for regulating the drainage of Syr Darya, I. H. Aleksandrov was convinced that Kara-Darya waters could be used for irrigation of about 500000 hectares, and this solution of the problem was to give the most rational distribution of water in the Syr Darya basin and release the waters of the Naryn for irrigation of the Dalversinskyi and Holodnyi steppes.

The project by I. H. Aleksandrov envisaged regulating the runoff of the Kara Darya by means of a large reservoir, in which water could be stored during the period when it was not needed for irrigation, and given to the river at times of lack of water in the irrigation network. Ivan Havrylovych considered the most suitable place to construct a reservoir near the village of Kampir-Rawat, where the high rocky shores converged at a close distance. All these circumstances, as I. H. Aleksandrov noted, allowed "comparatively profitable to build a dam and form a giant reservoir of water". The irrigation project of south-eastern Fergana was drawn up by I. H. Aleksandrov according to the materials of the exploration works, which were carried out for 4 years, from 1913 to 1917 (Aleksandrov, 1923a). The project impressed not only with the originality and brilliant technical design, but also with

the enormous research material, on the basis of which the author built undoubtedly the best irrigation scheme for that time.

Regarding his project in comparison with the proposals of the earlier period, Ivan Havrylovych gave the following considerations:

1. To irrigate the left-bank (southeast) Fergana the waters of the Kara Darya should be completely used; the waters of both Naryn itself and those stored in reservoirs located in the upper Naryn should be used completely for irrigation of the Holodnyi and Dalversinskyi steppes and lands in the lower reaches of the Syr Darya.

2. The Kara Darya water should be used more sparingly, since winter runoff should also been fully utilized.

3. The length of the main canal and with it the amount of wasted water should be reduced.

4. The need to construct a large aqueduct through the Kara Darya is then eliminated.

5. The channel route should go higher than planned in the project of private entrepreneurs. Due to this, a large amount of land was involved in the irrigation area and water use was regulated over a large area. In other words, the "command area" is expanding, that is, the irrigation area by the waters of this large channel.

6. In the area of subordination to the channel there were included the lower sections of Ak-Bura, Aravan-Sai, Isfayrak and Shakhimardan systems, which were not sufficiently provided with water.

7. The use of differences in the rivers' flows to generate electricity should pay back the cost of their construction and give a sufficient amount of energy to supply Fergana (Aleksandrov, 1923a, p. 179).

The proposal to use the hydraulic differential energy was first put forward by I. H. Aleksandrov in the hydraulic engineering and science. It was a very important innovation in the creation of irrigation facilities. For the first time, a prominent engineer considered the close combination of irrigation problems with the wide and rational application of water resources of Central Asian rivers (Aleksandrov, 1923b).

Large-scale studies of this kind are supposedly "harbingers" of his later projects of large hydropower plants (including in Central Asia). Yet while conducting research in the Syr Darya basin, Ivan Havrylovych confidently predicted the great importance of the Central Asian rivers as a powerful source for obtaining cheap electricity. Of course, he considered receiving this energy in connection with the construction of irrigation facilities. Proposed by I. H. Aleksandrov, ideas about combining irrigation tasks with obtaining cheap electricity through installations built on large irrigation canals and dams of reservoirs were absolutely original in technical terms. These ideas, further developed by Ivan Havrylovych and other home scientists and engineers, led to the remarkable successes of the complex design of hydropower structures in the former USSR.

The preparation of the irrigation project for south-eastern Fergana and the Tashkent region was preceded by extensive work on the study of the Syr Darya basin, the results of which were outlined by I. H. Aleksandrov in articles and separate

publications: "Surveys on the arrangements of reservoirs in the upper reaches of the Syr Darya River" (1914) (Aleksandrov, 1914), "Regime of rivers of the Syr Darya River Basin" (1923) (Aleksandrov, 1923c), "Regulation of the flow of the Syr Darya River and prospects of irrigation in its basin" (1923) (Aleksandrov, 1923d) and others.

Ivan Havrylovych realized that only new forces and hard work would be able to turn backward and beggarly Turkestan of those times into the area of innumerable people's riches, "... the development of material culture in the Tashkent region," the scientist wrote, "will always be connected with the development of irrigation and energy supply, since no crops are possible at all in Turkestan without irrigation, and energy is important especially in Tashkent region, which promises to become the main industrial centre of Turkestan in the future, deep wounds caused to the economy in the last decade, will quickly heal with the friendly work of the young forces" (Aleksandrov, 1923b, p. 56).

## Conclusions

On the basis of a large number of sources it is determined that occupying various positions I. H. Aleksandrov successfully participated in solving complex technical issues of hydraulic engineering. One can substantiate that scientific researches by I. H. Aleksandrov were carried out in the context of the challenges of the engineering science of his time. Scientific and creative contribution by I. H. Aleksandrov can be divided into five main directions of science and technology development: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation. The hydraulic engineering period in the scientific activities by I. H. Aleksandrov was the first where the future Academician applied his knowledge, skills, enormous organizing abilities, and proved his potential. The ideas of I. H. Aleksandrov were frequently linked with scientific ideas and concepts of his predecessors: P. P. Melnykov, D. I. Zhuravskyi, M. A. Beleliubskyi, S. D. Kareisha and others. However, they always were creatively re-thought by the talented scientist and engineer (Isaienko, 2013). It demonstrates that the works of I. H. Aleksandrov is a significant contribution to the development of hydraulic engineering and hydropower science, through which the scientist occupied the position of one of the leading scientists and brightest engineers of his time.

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## Внесок академіка І. Г. Александрова у розвиток гідротехніки (на прикладі наукових та інженерних підходів до проблем іригації Туркестану)

***Анотація.*** *Історія науки та техніки як галузь наукових знань спрямована на вивчення найбільш значущих ідей видатних вчених та практиків та їхній вплив на просування цих технологій та світовий розвиток науки. На думку авторів статті, однією з таких фігур початку XX століття є академік І. Г. Александров. Історичний та науковий аналіз життя та діяльності І. Г. Александров як наукового теоретика, інженера, організатора науки вирізняється високою актуальністю завдяки масштабності та універсальності його наукового внеску. Науково-творчу роботу І. Г. Александрова можна розділити на п'ять основних напрямків розвитку науки і технологій: гідротехнічне будівництво, гідроенергетика, географічне районування, залізничний транспорт та зрошення. У контексті розвитку гідротехніки та гідроенергетики І. Г. Александров мав досягнення світового рівня, які прославляли національну науку. Але до останніх років І. Г. Александров здебільшого визнаний проектантом і одним із будівельників Дніпровської ГЕС поблизу Запоріжжя (1927-1932) (він підготував проект і керував будівництвом найбільшої на той час в Європі гідроелектростанції) або ж як творцем та розробником методології економічного районування*

*Радянського Союзу. Інші досягнення та ідеї академіка І. Г. Александрова рідко згадують у наукових працях та дослідженнях. У статті робиться висновок, що широта науково-технічних інтересів І. Г. Александров була результатом як його індивідуальних здібностей, так і ретельної теоретичної та практичної підготовки, яку отримав молодий інженер І. Г. Александров від висококваліфікованого викладацького складу Московського вищого технічного училища та Московського інженерного училища Управління шляхів сполучення. Гігантська працездатність І. Г. Александрова також відіграла важливу роль у його житті. Велика кількість джерел показала, що займаючи різні посади, І. Г. Александров брав участь у вирішенні складних технічних завдань сучасної йому епохи, а його наукові інтереси завжди були в контексті завдань інженерії та науки того часу. І. Г. Александров ініціював наукові дискусії щодо будівництва портів і каналів, у своїй роботі він всіляко сприяв розвитку вітчизняної промисловості загалом, та гідротехніки зокрема. Автори стверджують, що сучасний погляд на наукову спадщину І. Г. Александрова у контексті розвитку гідротехніки, гідроенергетики та залізничного транспорту однозначно визнає, що в концентровано-узагальненому вигляді ідеї, теорії та концепції, висунуті та науково обґрунтовані академіком І. Г. Александровим майже сто років тому навіть сьогодні сприяють розвитку науково-технічного процесу.*

***Ключові слова:*** *І. Г. Александров; гідротехнічне будівництво; проекти зрошення; проекти енергопостачання; регулювання течії річки*

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## Вклад академика И. Г. Александрова в развитие гидротехники (на примере научных и инженерных подходов к проблемам ирригации Туркестана)

***Аннотация.*** *История науки и техники как отрасль научного знания направлена на изучение наиболее значимых идей выдающихся ученых и практиков и их влияния на развитие мировой науки и развитие технологий. По мнению авторов статьи, одним из таких деятелей начала XX века является академик И. Г. Александров. Историко-научный анализ жизни и деятельности И. Г. Александрова как научного теоретика, инженера, организатора науки имеет высокую актуальность благодаря масштабности и универсальности его научного вклада. Научно-творческую работу И. Г. Александрова можно*

*разделить на пять основных направлений развития науки и техники: гидротехника, гидроэнергетика, географическое районирование, железнодорожный транспорт и ирригация. В контексте развития гидротехники и гидроэнергетики у И. Г. Александрова были достижения мирового уровня, которые прославляли отечественную науку. Но до последних лет И. Г. Александров в основном известен как проектировщик и один из строителей Днепровской ГЭС под Запорожьем (1927-1932) (он подготовил проект и руководил строительством крупнейшей на то время гидроэлектростанции в Европе) или как создатель и разработчик методологии экономического зонирования Советского Союза. Другие достижения и идеи академика И. Г. Александрова редко упоминаются в научных работах и исследованиях. В статье делается вывод о том, что широта научно-технических интересов И. Г. Александрова была результатом, как его индивидуальных способностей, так и основательной теоретической и практической подготовкой, полученной молодым инженером И. Г. Александровым от высококвалифицированного профессорско-преподавательского состава Московского высшего технического училища и Московского инженерного училища Управления путей сообщения. Гигантская работоспособность И. Г. Александрова сыграла важную роль и в его жизни. Множество источников показали, что занимая разные должности, И. Г. Александров участвовал в решении сложных технических вопросов современной эпохи, и его научные интересы всегда были в контексте задач техники и науки его времени. И. Г. Александров инициировал научные дискуссии о строительстве портов и каналов, в своей работе он всячески способствовал развитию отечественной промышленности в целом и гидротехнике в частности. Авторы утверждают, что современный взгляд на научное наследие И. Г. Александрова в контексте развития гидротехники, гидроэнергетики и железнодорожного транспорта однозначно признает, что в концентрированно-обобщенном виде идеи, теории и концепции, которые выдвигаются и научно обосновываются академиком И. Г. Александровым почти сто лет назад, даже сегодня способствуют развитию научно-технического процесса.*

***Ключевые слова:*** *И. Г. Александров; гидротехника; ирригационные проекты; проекты энергоснабжения; регулирование стока рек*

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# Development of communication science, computer science and cybernetics in the 1940s – 1950s

***Abstract.*** *This publication presents the emergence of the new sciences that are most important for today's world: communication science, cybernetics, the theory of information, and the theory of the noosphere in the 1940s – 1950s. The purpose of this article is to analyze the total scientific achievements in Eurasia at the time of the Second World War. This was a bright phenomenon in the formation of new revolutionary theories. Works of Chicago-based and Frankfurt-based schools of thought, the theoretical concepts of T. Adorno, M. Horkheimer, H. Lasswell, P. Lazarsfeld, and other researchers laid the foundations of the communication science and contributed to the breakthrough in a number of the key subject areas. A system approach to and a comparative analysis of the causes and subsequent consequences of the achievements at that time for today's world served as a methodological basis for a comprehensive consideration of large-scale studies of the past. The scientific novelty of this historic study consists in the interdependence and complementarity of the theoretical and practical achievements in the 1940s and rethinking of their importance in the structure of concepts in the 20$^{th}$ century. Industrial and military goals associated with the automatic management and communication processes required fundamentally new approaches and achievements. When World War II broke out, N. Wiener worked on these problems aiming at creating a computer, which pushed him to the idea that the principles of managing biotic and abiotic systems are the same and to the cybernetic concept development. In the mid-1940s, J. von Neumann built the first digital computer. In 1945-1947, A. Turing worked, as an inventor of "a universal machine", on the "electronic brain" project and was the first to develop a number of programs for it. In 1942, C. Shannon published his work dedicated to the theory of information permitting a constellation of researchers to lay the foundations of the theory of communication. V. Vernadsky's noosphere concept proposed in 1944 was particularly important. At present, the ideas of that period are gaining new importance as a basis for the single planetary management system.*

***Keywords****: history of science; noosphere; theory of information; theory of communication; management*

## Introduction

The relevance of the management, information, and communication interaction in the 20th century science development history and an analysis of their role in the social evolution of the global civilization are triggered by transformation processes in many areas of society's life activities and crises occurring today. The processes of rethinking the nature and essence of communication in the public life, in the management of economic, social, and political activities launched in the second quarter of the 20th century resulted in fundamental scientific achievements in the 1940s and emergence of new sciences: theory of information, theory of communication, cybernetics, and theory of noosphere. An analysis of a particularly productive period of development of the communication science and management theories in the mid-20th century should contribute to the new rethinking of the past scientific ideas. This is necessary for better understanding today's crisis stage of the humankind development at the end of the first quarter of the 21st century.

The historical scientific heritage of the 20th century in the area of information, communications, and cybernetics was also described in the works of national researchers such as V. Ivanov, A. Kholod, L. Khomenko, V. Rezun, O. Zernetska, and others. Foreign researchers looking at that period and achievements of the thinkers of that time from today's perspective include N. Dergunova, O. Gnatyuk, M. Kuznetsov, A. Lerner, N. Luhmann, L. Matveeva, E. Wartella, F. Webster, M. Zavgorodnaya, and a number of other authors. However, this issue has not been adequately studied in a comprehensive and consistent manner.

Individual aspects of analyzes the role assessment and communication significance in state control systems in works and prominent representatives' statements of political thought from antiquity to the beginning of the twentieth century (in the 1920s – 1930s) (Kislov, 2019).

## Object

Reflect the processes of the communicology genesis, types and models of communications, sources and the basic paradigms of social communications, theoretical problems issues of different marketing communication integration and maintenance of an information exchange in communicative systems in the twentieth century to form the concept of how to turn communication into mass communication was formed into one of the key mechanisms forming state and public administration.

## Research methods

A system approach and a comparative historical analysis of research works that allowed making an information and technology revolution in the second half of the 20th century served as a methodological basis for a comprehensive study of the ideas and achievements of the thinkers working in the 1940s, which laid the foundations for the understanding of managerial, information and communication processes. A system analysis of research works of that period should contribute to the historical,

philosophic, and practical rethinking of the importance of works written in that period for the theoretical achievements in the second half of the 21st century.

**Results and discussion**

By 1940, all the preconditions based on a deep analysis of the role, methods, and technique of the propaganda, ways of the society development and management were available for the formation of a complex of new research areas. There were good conditions for the emergence of sciences that later changed the humankind development course: communication science, computer science, cybernetics, and the general theory of management. Two fundamental areas, two paradigms were formed to generalize a diversity of approaches to studies of the phenomenon of communication and communicativeness of human societies for decades to come. These scientific areas were defined as structural and functional, sociocultural ones. H. Lasswell, who proposed a concept of "indoctrination" (Lasswell, 1948), was one of the originators of the former. Earlier, in 1944, P. Lazarsfeld along with B. Berelson and H. Gaudet proposed a theory of a two-level flow of information (Lazarsfeld, Berelson, Gaudet, 1944). The researchers of the sociocultural area, based on socio-psychology, reduced the social role of communication to its utilitarian understanding as a system fulfilling its pragmatically preset functions. The theoretical justifications of this concept were developed a decade later.

In the 1940s, the Rockefeller Foundation offered to fund the projects involving the study of the media's impact on the electors' choice by engaging in these activities many researchers who had emigrated from Europe. Diverse and disparate works and data obtained in that area were generalized by P. Lazarsfeld, who determined the ways and methods of the efficiency of the media's communicative activities.

In 1941, T. Adorno started working on the "critical theory of society" at the Social Research Institute and, in 1942, jointly with M. Horkheimer, set out to develop the central theme of its work: criticizing the manipulative nature of technology used by the mass culture to form mental and behavioral stereotypes of a consumer society's ordinary members. In 1944, the first mimeographical book by M. Horkheimer and T. Adorno "Dialectic of Enlightenment" titled "Philosophical Fragments" was published in the USA. The book was published in 1947 in Amsterdam bearing its full title *(*Kuznetsov, 2011, p. 21*)*.

This book was the brightest work of the Frankfurt school. At present, it is still estimated to be one of the classic philosophic works of the 20th century. In their book "Dialectic of Enlightenment", the authors provided a brief and schematic exposition of a wide and multifaceted complex of philosophic ideas, describing a crisis situation prepared for the western culture and civilization in the 20th century (Horkheimer, Adorno, 1997). An analysis and a tough verdict of the civilized project of five centuries was based on the specific communicative strategy consisting both in the way of structuring the text of the work not corresponding to the generally acceptable standards of such treaties and in a special type of the discourse used, which appeals to the creative thinking of readers and rules out any mentor dictate. This was a sort of a

message and warning aimed at the next generations, i.e. the present-day society, about the problems that arose and continue arising as a result of the information and communications technology development *(*Kuznetsov, 2011, p. 41; Jensen, Craig, Pooley & Rothenbuhler, 2016).

Research of mass communication processes was particularly on the rise in the mid-1940s. This is when the conceptual understanding of communication based on the model methodology proposed by H. Lasswell in the early 1940s was established and developed. His formula published in 1948 and consisting of five elements modeling the process of communication exchange from the communicator to the recipient (audiences) includes the concept of efficiency (process efficiency) (Kislov, Romanenko & Chaplay, 2018, p. 9*).*

This component defining the practical communication efficiency asked questions that could be answered by cybernetics, a new science back then. American researcher and mathematician N. Wiener was its founding father. As World War II broke out, N. Wiener, guided by designing engineer V. Bush, participated in the creation of a computer for a ballistic analysis and gun control. This made him focus on the general issues of automatic management and principles of functioning of negative feedbacks in the automatic regulation systems. Work on these issues pushed him to the idea that the principles of managing biotic and abiotic systems are the same and to the cybernetic concept development. This subject area was also contributed by the theoretical work of A. Turing dedicated to the "universal machine", published in 1937. N. Wiener's famous book "Cybernetics: Or Control and Communication in the Animal and the Machine", published for the first time in 1948, gave rise to revolutionary events in the world of science and caused deep changes in the view of the world (Wiener, 1983). Later, N. Wiener's cybernetic concept was stated in his book "Cybernetics and Society". N. Wiener's ideas about the essence of information and entropy, their role in organization systems, the role of feedback as an optimization basis of the communication process had a direct impact on the later works that led to the creation of full-scale theories of information and communications.

N. Wiener's cybernetic ideas, achievements of H. Lasswell, P. Lazarsfeld, and other researchers concerning the communications modeling encouraged new ideas of the nature of information, laid the foundations of the computer science and the communication science. The theory of information was founded by American engineer and researcher C. Shannon, who relied on practical works dedicated to the improvement of means of communication, coding and decoding during World War II. According to C. Shannon, information in hardware and software is a message transmitted in the form of signs. In his theory of information, these are not just messages, but only those that change or reduce significant uncertainty. In C. Shannon's opinion, information means "removed uncertainty". His pragmatic approach made it possible to use quantitative methods of calculating information transmitted by means of communication (communication channels), which received its terminological definition in the European languages back in 1928, when

R. Hartley introduced this scientific term as a quantitative measure of messages. This was an artificial model restriction of the information phenomenon concept for the sake of its practical usage in studying means of communication. C. Shannon published his works while working at the Bell System mathematical laboratory in 1941–1957. He published his major works dedicated to the theory of information and communications in 1942-1949 (Shannon, 1948). He introduced the concepts of "bit" and "entropy", presented other fundamental definitions and mathematical formulas, proposed ideas still forming today's communications technology. C. Shannon's statement that "information is information, but not energy or matter" later pushed the humankind to become fully aware of this fundamental phenomenon of nature. And then the picture of understanding management and communications would be clearer and more accurate (Shannon, 1963).

In 1942, the Palo-Alto (a small town near San Francisco) school focusing on communications was formed. Its activities relied on N. Wiener's circular model of communications considered in terms of various social sciences. From the perspective of this approach adopted by this school consisting in the same role of the information receiver and sender (recipient and communicator) in the joint circular communication process, this school's researchers proposed the following hypotheses: concerning the driving force of communications; the logic of communications (the succession of messages and dependence between the elements of the communication system). It was also found out that communications as a verbal act are opposed by communications as a permanent social process covering various types of activities (speech, gesture, look, etc.).

E. Hall, one of the most important representatives of this school, continued and developed the ideas of the 1940s. In 1954, E. Hall and G. Trager published their work titled "Culture as Communication: A Model and an Analysis", which summarized the first results of studying the behavior and communications of people of various cultural backgrounds launched in the USA back in 1947. It introduced the term "intercultural communication" for the first time. In their studies, the authors proved that it is the basis of human relationships and interactions (Trager & Hall, 1954). E. Hall discovered a link and interaction between culture and communications and proved that different cultures can be compared based on the grounds that are common for all the cultures. Later he developed the basics of proxemics – an area of science focused on the space and time phenomenon in communications. He studied the impact of tools of labor and other factors on their coherence and compatibility with the perception of messages of the media and means of communication (Hall, 1959) These works are particularly valuable for analyzing today's political discourse in Ukraine.

In 1935, prominent English mathematician A. Turing engaged in research work according to the mathematical logic, which led him to the idea of the famous abstract "Turing Machine" described in 1936-1937. Work on the "machine-concept" allowed him to articulate the algorithm concept and be considered one of the founding fathers of the computer science. Over a period from 1939 to 1945, he worked at the

Communications Department of the Foreign Office of England. Having found out that new computers were actually created based on the principles of his "universal machine" without being directly familiarized with his research works, he got employed by the National Physics Laboratory. Later, A. Turing engaged in the development, engineering, and use of "electronic brain" in management: ACE, a huge automatic computer, and was the first to develop a number of programs. Afterwards, he focused on the training of "thinking machines" and development of mathematical support in engineering computers at the University of Manchester (Lerner, 1967, p. 183).

In the mid-1940s, J. von Neumann, one of the most universal intellects of the 20th century, created the first digital computer and published, in 1944 along with O. Morgenstern, the first systematic fundamental study dedicated to management in conflict situations: "Theory of Games and Economic Behavior". Later, J. von Neumann worked on plausible problems of development and evidence of the capacity of quite sophisticated automatic management systems to reproduce themselves and even synthesize more sophisticated systems. He justified a possibility of "synthesizing reliable organisms from unreliable components" by introducing structural excessiveness. With these works, J. von Neumann opened new areas in cybernetics and in the general theory of management *(*Lerner, 1967, p. 247).

Without disparaging the merits of N. Wiener, C. Shannon, A. Turing, J. von Neumann, and their followers, it should be emphasized that some main provisions of management theories had previously been developed for many years, and some ideas even for centuries. Ideas of creating computers were proposed by B. Pascal and G. Leibniz in the 17th century. Ch. Babbage proposed a project of a universal programmable computer in 1833, which was a more developed prototype of modern computers. The theory of regulation by J. Maxwell and the theory of feedback systems by I. Vyshnegradsky began to be developed in the 1860s – 1870s. In the 20th century, their ideas were used in the theory of automatic management of production systems. At the same time, there were proposals to develop a general theory of management, but it still continues to be fully formed even today.

During the aforementioned period, American and European science of social management was limited to the principles and provisions stated in the early 20th century by F. Taylor, H. Fayol, H. Ford, H. Emerson, and other authors. H. Fayol's book "General and Industrial Management", published in France in 1916, focused on the main ideas and principles of administrative management of human societies. Attempts to bring together the disparate industry-related theories of machine, production, and social management as a single concept made before the mid-1920s continued into the mid-20th century as well.

The nature of comprehensive planetary management of human activities and natural processes was described in the noosphere concept proposed by national research and erudite V. Vernadsky. It is articulated in his last works as a philosophic, scientific, and political testament to humankind. V. Vernadsky believed that his model concept developed in 1936-1943 pointed to the natural spontaneous process

that will help progressive humankind get the final victory in its struggle for planetary management. V. Vernadsky's final article "A Few Words about the Noosphere" was published in 1944, although a number of scientists from many countries around the world got familiar with V. Vernadsky's ideas in 1938 (Vernadsky, 1944). The general scientific community learned about the concept of noosphere only after the publications starting from 1965 (Halyna Shvetsova-Vodka, 2018).

Back then and even decades later, the noosphere concept was narrowed as it was considered in strictly abstract scientific terms. V. Vernadsky's main idea, according to which progress in history aims at uniting humankind under general planetary management or at the noosphere as a future unity of the human organization in the rational efficient structure harmonically coexisting with the biosphere, was practically ignored. According to the philosopher, noosphere will be quite real and unavoidable when all the components for the general management of the global civilization management are at hand. However, the authors interpreting the theoretical art heritage of this researcher and erudite missed the communicative components of real transition to the noosphere clearly emphasized in V. Vernadsky's final research work.

These conditions began to be really implemented by the modern civilization in the 21st century. There is still a long way of evolution to fully achieve them. Taking into account V. Vernadsky's paradigm, it is clear that the global civilization should overcome the system crisis by starting with the management structures of international, continental, and national levels based on fundamental changes in the main paradigm of the human society development on Earth. This can be possible only by taking into account the conceptual principles and conditions of gradual and consolidated development of the practical noosphere – transition from the availability of a certain quantitative composition of the "homo sapiens" to the "sphere of the global civilization intelligence synthesized with the biosphere".

Under the influence of the said scope of research works that opened new areas in human activities, some American and western European universities set up departments of communications, theory, and practice of management, where they developed methods of training specialists for such spheres, introduced academic courses, including those dedicated to communications and communications technology. Many researchers were then involved in open-end research into new areas of cybernetics, computer science, semiotics, and communication science, which justified a new or particular understanding of the nature of communications and management.

## Conclusions

The main ideas and achievements of researchers studying the nature of information and communications processes and management in the 1940s proved to be a real fundamental scientific and technological event that triggered deep changes in many world view paradigms. They had a significant impact on the practical activities in various industries of the global economy. Practice proved and enhanced

the general importance of achievements of those years, which became real as a result of past developments, practical war-time demands, intensification of current developments and concentration of better intellects and promoters of advanced scientific ideas for this purpose. A possibility of relatively free self-development and originality of interactions within informal research schools provided to researchers additional conditions for successful breakthroughs in the area of most progressive sciences predetermining the development of an information and technological revolution.

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## Формування комунікативістики, інформатики та кібернетики у 1940 – 1950 роки

***Анотація.*** *У статті розглядається процес становлення комунікативістики, теорії інформації, кібернетики та теорії ноосфери як комплексу нових наук в 1940-1950 роки. Метою статті є аналіз подій, коли в умовах Другої світовій війни особливо виразним періодом для формування нових революційних наукових теорій стали США. На основі наробок вчених Чиказької та Франкфуртської шкіл, теоретичних праць Т. Адорно, П. Лазарсфельда, Г. Лассуелла й багатьох інших вчених до 40-их років було закладено ґрунтовну базу для швидкого й широкомасштабного прориву в багатьох галузях знань і, насамперед, у тих, що були пов'язані з проблемами управління у машинних і людино-машинних середовищах, а також у технологіях комунікації на основі радіо та перших телепередач. Методологічною основою для комплексного розгляду широкомасштабних досліджень того часу став системний підхід і порівняльний аналіз причин та майбутніх наслідків від досягнень тих років для сучасності й подальшого розвитку XXI сторіччя. Наукова новизна цього історичного дослідження полягає у комплексному показі взаємообумовленості та взаємодоповнюваності теоретичних і практичних розробок 40-х років для новітнього переосмислення їх значення в структурі концепції глобального управління, до створення якого підійшло людство перед початком 20-х років XXI сторіччя. З початком Другої світової війни Н. Вінер під керівництвом В. Буша бере участь у розробках електронної обчислювальної машини для*

*балістичних розрахунків та управління артилерійським вогнем і це змушує його приступити до досліджень загальних основ автоматичного управління та принципів від'ємних зворотних зв'язків у системах автоматичного регулювання. Ця робота призвела Н. Вінера до ідеї про єдність принципів управління в живих і неживих системах, що у свою чергу дало поштовх до формування кібернетичної концепції. На цьому підґрунті теоретичні піонерські розробки А. Тюрінга про принципи побудови "універсальної машини", описаної ним ще у 1937 р., були як ніколи доречні. В середині 40-х років Дж. фон Нейман побудував першу цифрову електронну обчислювану машину, а А. Тюрінг з 1945 по 1947 роки на чолі групи співробітників розробив проект "електронного мозку" та першим підготував ряд програм і розпочав роботи з навчання електронних машин. К. Шенноном було закладено наукові засади подальшого розвитку теорії інформації й теорії комунікації, що дало потужний поштовх науковим дослідженням на багато десятиліть потому. Особливе значення має виникнення основ теорії ноосфери В. Вернадського, яка тільки в XXI сторіччі набуває розуміння у поєднанні з комунікативістикою та загальною теорією управління. Цей комплекс основ нового наукового світобачення був вирішальним у процесі розвитку інформаційно-технологічної революції та становленні інформаційного суспільства у другій половині XX сторіччя. У наш час наукові ідеї того періоду стають теоретичною основою єдиної загальнопланетарної системи управління.*

***Ключові слова**: історія науки; ноосфера; теорія інформації; теорія комунікації; управління*

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## Формирование коммуникативистики, информатики и кибернетики в 1940 - 1950 годы

***Аннотация.** В данной публикации представлено становление наиболее актуальных для современности новых наук: коммуникативистики, кибернетики, теории информации и теории ноосферы в 1940-1950 годы. Целью статьи является анализ событий, когда в условиях развернувшейся на просторах Евразии Второй мировой войны особенно ярким периодом для формирования новых революционных научных теорий стали США. Работы Чикагской и Франкфуртской научных школ, теоретических концепций Т. Адорно, П. Лазарсфельда, Г. Лассуэлла и других ученых заложили к этому времени хорошую основу для мощного прорыва в ряде ключевых отраслей знаний и в общем цивилизационном мировоззрении. Методологической основой для комплексного рассмотрения широкомасштабных исследований того*

*времени послужил системный подход и сравнительный анализ причин и грядущих последствий достижений тех лет для современности и ближайшего будущего XXI века. Научной новизной данного исторического исследования является показ взаимообусловленности и взаимодополняемости теоретических и практических разработок 40-х годов для нового осмысления их значимости в структуре концепции общепланетарного (ноосферного) управления, к разработке которого подошло человечество к началу 20-х годов XXI века. Производственные и военные задачи, связанные с автоматическим управлением в машинных и человеко-машинных средах, с коммуникационными процессами, использующими радио и первые телепередачи, требовали принципиально новых подходов и разработок. С началом Второй мировой войны Н. Винер под руководством В. Буша принимает участие в работе над созданием электронной вычислительной машины для баллистических расчётов и управления артиллерийским огнём и это вынуждает его заняться общими вопросами автоматического управления и принципами функционирования отрицательных обратных связей в системах автоматического регулирования. Работа над этими проблемами приводит Н. Винера к идее о единстве принципов управления в живых и неживых системах, к разработке начал кибернетической концепции. В русле этого направления была также теоретическая работа А. Тьюринга по "универсальной машине", опубликованная в 1937 г. В середине 40-х годов Дж. фон Нейман строит первую цифровую электронную вычислительную машину, а в 1945-1947 годах А. Тьюринг с соратниками работает над проектом создания "электронного мозга" и первым готовит ряд программ, приступив к "обучению" электронных машин. В 1942 г. К. Шеннон публикует работу по теории информации, в дальнейшем целой плеядой исследователей разрабатываются основы теории коммуникации. Особое значение имеет выдвижение в 1944 г. концепции ноосферы В. Вернадского. В настоящее время комплекс научных идей, выдвинутых в 40-е годы, обретает новое значение для формирования основ единой общепланетарной системы управления.*

***Ключевые слова**: история науки; ноосфера; теория информации; теория коммуникации; управление*

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## "Essay on the history of fossil ungulates" by Academician M. V. Pavlova as phenomenon in the world palaeozoological science (end of the nineteenth and early twentieth centuries)

***Abstract.*** *The objective of the research is to reveal the main areas of research of Academician M. V. Pavlova in scientific works "Essay on the history of fossil ungulates" in the late nineteenth and early twentieth centuries, to show the contribution of these works to the world of palaeozoological science. The scientific novelty is that the life path and academic heritage of academician M. V. Pavlova was investigated in complex in the context of the development of Palaeozoology for the first time in Ukrainian historiography, and her scientific biography was reconstructed; the history of domestic palaeozoology is presented through the prism of M. V. Pavlova work and her scientific school; the published and handwritten works of the scientist were analyzed, which enabled to deepen the knowledge about the history of the national palaeozoological science and its influence on the development of world science. She demonstrated the importance of fossil mammal research for stratigraphic constructions. The founder of paleontology, as a scholarly discipline, is considered a prominent George Cuvier. Also, Paleontology and its section of Palaeozoology were created, such world-renowned scholars as Albert Godry, Otniel Marsh, Edward Cop, Volodymyr Kovalevsky, Melchior Neumire, Louis Dollo, Henry Osbourne, and others. To this galaxy of scientists-paleozoologist belongs also our compatriot, academician M. V. Pavlova (1854-1938). It was established that Maria Vasylivna Pavlova (in the girlhood M. V. Gortynskaya) is an entire era in the development of Palaeozoology. She is an outstanding specialist in the study of fossil mammals, the organizer and promoter of Palaeozoology Science. Maria Vasylivna is a world-class paleozoologist, a well-known specialist in scientific circles who was personally familiar with many prominent paleo scientists, for example, Albert Godri, who was her teacher at the Sorbonne, and with Henry Osborne she studied together at the same university, supported the connections with him all her life. The first woman-paleontologist, woman-professor, female academician in the Russian Empire, thanks to whom the domestic paleontology was allocated to independent biological science and which, with its research, laid the*

*foundation for the development of paleontology (palaeozoology) in Ukraine. Works on the history of a large number of groups of fossil ungulates ended one of the cycles of M. V. Pavlova works, that showed the monophyletic development of most of the ungulates, the number of Tertiary and Quaternary faunas in the territory of the Russian Empire and in general in Ukraine.*

***Keywords:*** *palaeozoology; paleontology; science; evolution; ungulates; fossil mammals*

## Introduction

During the last decade there have been some changes in the mastering of the scientific work of M. V. Pavlova. This was manifested in the article by R. O. Chavrin (Chaurin, 2000), in the articles by Z. A. Bessudnova (Bessudnova, 2004; Bessudnova, 2009), the manual "Paleozoology" B. K. Kotti (Kotti, 2011), Biographical information of the archivist of the Russian Academy of Sciences in Moscow V. M. Zagrebayeva (Zagrebayeva, IS ARAN) and in the general works of the author of this study (Deforzh, 2011; Deforzh, 2015a; Deforzh, 2015b). Unfortunately, in the scientific literature there were few examples of the reprinting of M. V. Pavlova works in the current time, insufficiently highlighted her epistolary heritage, little analytical publications about her scientific achievements. The author of this study carried out the classification of the entire complex of sources used in the work in 4 groups: 1) scientific works of M. V. Pavlova; 2) documentary sources; 3) materials of personal origin: autobiography, form list and epistolary inheritance; 4) scientific and journalistic literature about M. V. Pavlova.

In the process of studying the literature about the life and work of M. V. Pavlova three periods should be distinguished. The first is the literature on the so-called "period of the Russian Empire" (1886-1917) that covers 31 years, the second is from the Soviet period, which is the largest – 74 years, the third is in the modern period of development of a problem that spans only 24 years.

**The purpose** of the publication to reveal the main directions of research of Academician M. V. Pavlova in scientific works "Essays on the history of fossil ungulates" at the end of the nineteenth and early twentieth centuries, to show the contribution of these works to the world of palaeozoological science.

## Research methods

The methodology of the research is based on the use of chronological, typological, comparative, personological methods of historical knowledge, classification and systematization of historical sources, which made it possible to highlight the main point in the study of this topic (Deforzh, 2019).

## Results and Discussions

Maria Vasylivna Pavlova is an outstanding scientist-paleozoologist, a geologist and paleontologist, a doctor of geology, a professor (1910), an honored professor, an academician of the Academy of Sciences of the USSR (1925), Honorary

Academician of the USSR Academy of Sciences (1930), Honored Worker Science of the RSFSR (1928), Honorary Member of the Paleontological Society, Director of the Geological Paleontological Museum and the Head of the Department of Paleontology of the Moscow University (1919-1930). The wife of one of the most prominent Russian geologists in the late nineteenth and early twentieth centuries Aleksii Pavlov (1854–1929).

Half a century scientific activity of M. V. Pavlova laid a solid foundation not only for domestic evolution paleontology (paleozoology), which is now being developed by a large number of researchers (Smirnov, 2013). It contributed to the paleontological foundation of stratigraphy of the Continental Neogene and Quaternary deposits of Western Europe. M. V. Pavlova created a school of paleozoology, paleontologists-stratigraphs. Among her students there are well-known scientists as V. V. Menner, M. O. Bolkhovitinova, V. V. Teriaiev, M. I. Shulga-Nesterenko and others.

M. V. Pavlova had a wonderful ability to attract people. Her kindness, the desire to help, exceptional goodwill and light humor attracted people of different specialties to her. This led to widespread popularity of Maria Vasylivna both in the USSR and abroad. M. V. Pavlova was elected as a member of the French Zoological Society, the Geological Society of France, the Geological Society of London and the Linnaeus Society in Lyon (France). In 1926 M. V. Pavlova and O. P. Pavlov became the laureates of the highest award of the Geological Society of France – the prize of Albert Godry.

Maria Vasylivna always sought to find something new in all the many directions of Paleozoic Science, which she had to deal with, tried to look at them from an unusual side. She had always been looking for new factual material without regretting her time for it. Owning a huge amount of diverse data allowed her to make the right conclusions, which still remain relevant today. Maria Vasylivna as a patriot of science of Paleozoic always sought to enhance her prestige.

An analysis of the scientific heritage of Academician M. V. Pavlova, a prominent domestic paleo-scientist, a specialist in the field of evolutionary theory, an organizer of Paleozoic Science and a teacher, makes it possible to understand the processes of development of domestic biological science. She holds one of the honorary places in the world of paleontological science. Her name is associated with the development of Paleozoic Science at the end of the nineteenth – first third of the twentieth century and the scientific outlook on the development of various palaeozoological concepts, laws and ideas.

The first work of M. V. Pavlova, dedicated to fossil mammals (ungulates), saw the world in 1887. In fact, with this work, Maria Vasylivna launched the production of the famous series of works "Essays on the history of fossil ungulates" from America and Europe. Having chosen such a direction of palaeozoological research, M. V. Pavlova decided to highlight the development of the main groups of fossil ungulates in this series. She has steadily continued her research on this issue for 20 years. She has systematically published separate essays of this series in the "Bulletins

of the Moscow Society of Testers of Nature". From 1887 to 1906 there were 8 issues of this series in "Bulletins ...", and the last, 9th issue, in "Notes from the Petersburg Academy of Sciences".

Maria Vasylivna began publishing her research with a report "On the History of Fossil Ungulate Mammals" at a meeting of the Moscow Society of Naturalists in 1888. Her report was based on V. O. Kovalevsky representations about the evolution of ungulates.

"Essays on the history of fossil ungulates" with a special brightness reveal the main features of scientific creativity of M. V. Pavlova, those goals and tasks that she set before her in the first stage of their scientific activities. As can be seen from the contents of the whole series, the purpose of M. V. Pavlova was not only to cover the general history of the development of the most important groups of ungulates on the basis of already well-known materials of Western Europe and America, but above all on the basis of such coverage of the development of the organic world on the territory of Russia and Ukraine. Data on this before the beginning of research M. V. Pavlova was practically absent. This explains the proposed division of the series into four parts: "History of the ancient ungulates", "Development of horses", "Development of rhinos and tapirs" and "History of development of falcon Tertiary and Quaternary periods". Each of these parts, except for the first one, which is based only on American and Western European materials, consists of: a) review of the development of forms known from Western Europe and America based on a critical revision of literature and materials; and b) a description of the remains found on the territory of the Russian Empire, which are divided in fecundity and non-pernicious species by age, with a focus on the development of Tertiary and Quaternary groups mammals.

For writing the first articles M. V. Pavlova worked in all the great museums of Western Europe and America, using for this purpose his stay at the International Geological Congresses (she and her husband O. P. Pavlov visited almost all foreign congresses and congresses). In her work she had to rely on the materials already described and even on the materials repeatedly reconsidered by her by many prominent paleontologists of the world, and one can only be surprised by the exceptional observation and persistence of the young scientist who was able to obtain such results on the fossil material that immediately put it on a leading place in the world of Paleozoic Science.

Series "Essays on the history of fossil ungulates" M. V. Pavlova divided into 9 issues. The first one examines the history of the development of the ancient ungulates, and in subsequent editions the history of the development of equine, rhinoceros, tapirs and the history of the evolution of larvae is covered. Maria Vasylivna began each issue with an overview of the literature and the development of Western European and American forms. These reviews of M. V. Pavlova were written as a result of a personal study of materials stored in foreign museums and a critical review of literature. The text below is a description of the remains discovered on the territory of the Russian Empire. In each part, in close connection with the

material described, Maria Vasylivna considered a certain theoretical issues of general significance.

The first essay series of M. V. Pavlova's "Essays on the history of ancient fossil ungulates" is devoted to a group of primitive antiquity (Eocene) ungulates (Pavlow, 1887). In this work, Maria Vasylivna pointed to the proximity of European and American Paleogene neoprene and emphasizes their origin from one trunk. She analyzed the scientific articles of the American paleo-scientist E. Cope, in particular, compared the fossil remains of the ancient ungulates of America with the European ones and denies the conclusion of E. Cop, who pointed to the polyphyletic origin of the Eocene ungulates. Such a comparison allowed M. V. Pavlova to persuade Palaeozologists that a peculiar long-term group of condylartrum is very close to the pedigree barrow of the equestrian. The presence of certain forms of condylartrum attributes that approximate them to predatory and insectivorous animals, Maria Vasylivna considered as evidence of their primitiveness and the kinship of the initial forms of all rows of placental mammals. In general, in this first Paleozoic Labor, M. V. Pavlova clearly manifested her idea of the monophyletic development of the entire group of ungulates. This conclusion contradicts the statement of American Paleozoicologists and, as it turned out later, was confirmed by further research.

In the following, 1888 the second article of M. V. Pavlova "Development of the Horses" appeared (Pavlow, 1888 a). Maria Vasylivna classical review was based on the data of the classic monograph V. O. Kovalevsky "On anchor and paleontological history of equines" (Kovalevsky, 1948). In her article, Maria Vasylivna demonstrated how important it was to study the development of a family of equidae (Equidae), and also pointed to the interest that constitutes the study of the genealogy of the horse. She stressed that among vertebrates the family of horses is the most favorable object for phylogenetic constructions as ammonites among invertebrates.

Maria Vasylivna, although based on the monograph V. O. Kovalevsky, however, used for her constructs and conclusions much more material, compared with that which was at the disposal of V. O. Kovalevsky In the essay "Development of Horses," she reasonedly confirmed the monophyletic origin of the horse. It is extremely important for her statement about the location of the long-haired late-breeder horse-hipparion in the horse's development line (Pavlow, 1889 b). Before the research of Maria Vasylivna, the hippoparion was considered to be the ancestor of horses. And she convincingly showed that he was a lateral branch, which should be excluded from the direct trunk of the development of the horse. After all, gipparions are more primitive horses, they have triple limbs, more complex structure of teeth and many other different morphological differences. Everything testifies to the fact that the hipparions could not be direct ancestors of the horse. Of course, this statement of Maria Vasylivna contrasted with the generally accepted at that time point of view. However, she, like her husband O. P. Pavlov, attached great importance to the identification of lateral branches in the history of the development of certain groups of animals. Scientists believed that these branches were one of the proofs of the course of the evolutionary process in difficult natural conditions, where adaptation to

certain conditions did not always go in one definite way. That is why Maria Vasylivna repeatedly returns to the discussion of the place of the gipparion in the line of the horse. She devoted a few articles to this issue: "Etudes sur l'histoire Paléontologique des ongules en Amerique et en Europe. IV Hipparion de la Russie" (1889); "Etudes sur l'histoire Paleontologique des ongules en Amerique et en Europe. V. Notice to the Hipparion crassum du Rodssillon (1891); "Etudes sur l'histoire Paleontologique des ongules en Amerique et en Europe. VI. Qu'est ce que c'est que l'Hipparion (1891) (Pavlow, 1889a; Pavlow, 1891a; Pavlow, 1891b).

Thus, in the 4th, 5th and 6th issues of the specified series, M. V. Pavlova described gipparions and horses found in the sediments of southern Ukraine. And already on the basis of this new material, she checked the conclusions of her first work. This material allowed Maria Vasylivna to convincingly substantiate the monophyletic origin of horses from the American form of protogippus and highlight the conditions for the emergence of individual parts of this chain (Pavlow, 1903).

Point of view M. V. Pavlova to the location of the hippoparion and palaeoteria in the evolutionary series of horses became dominant in the early twentieth century. It was developed by G. Osborne and other researchers in the work on the development of horses in America. True, there were attempts to return to the old ideas about the origin of the horse from the hypoparion, but detailed revisions of this issue, which were held in the 1940s and 1950s, on our domestic material (V. I. Gromov), on American material, etc., are confirmed by M. V. Pavlova about the monophyletic origin of horses and about the specialization of the dental system of the hippopionus, which does not allow it to be attributed to the direct ancestors of the horse (Pavlow, 1925, p. 103).

The third issue of the series "Essays", which appeared in 1888, was devoted to the development of ancient rhinos and tapirs (Pavlow, 1888 b). Investigating these animals, M. V. Pavlova made some conclusions, which sharply differentiated from the generally accepted views at that time, and therefore initially objected. But his conclusions Maria Vasylivna reasonably and convincingly argued that after some time they were confirmed by prominent paleontologists (K. Kittel, L. Ruthieheimer, R. Lidecker, etc.). This scientific work of Maria Vasylivna on fossil rhinos and tapirs was highly praised by the American paleontologist E. Kop, although his own M. V. Pavlova has repeatedly criticized.

In 1903, Maria Vasylivna published the 6th issue of his Essays on the history of rhinoceros, using domestic material and involving data on fossil rhinos in Europe and America (Pavlow, 1890). In this work, special attention should be paid to the construction of genetic series based on a detailed study of teeth and extremities and their detailed changes during evolutionary development. In this publication, Maria Vasylivna seeks to give a biological assessment of these traits and necessarily relies on the law of irreversible evolution and criticizes the views of E. Kop and other supporters of neolamarckism.

In his phylogenetic constructions M. V. Pavlova removed a number of large groups from direct genealogical lines. A considerable attention in these works was

paid to the assessment of the biological significance of individual features, and to tracing their changes in the course of the development of the rhinocerous group. The irreversibility of the evolution process M. V. Pavlova considered this as one of the most important criteria.

In 1901–1906, M. V. Pavlova studied the main trends in the development of falconry (Pavlow, 1901a; Pavlow, 1901b; Pavlow, 1906). In accordance with the views of V. O. Kovalevsky, she considered the role of the adaptive and nonadaptive reduction of limbs in the development of fecundity, on the origin of pig and ruminant forms of four-cylindrical teeth. She critically criticized the views of E. Cope on the development of ferns from forms with five-pointed teeth, and proved the affiliation of such forms to blind specialized branches with nonadaptive reduction of the limbs, and not to simple primitive middle groups. Such studies of M. V. Pavlova reproduced a general picture of the development of larvae in time. She later was supported by her researches by outstanding Russian paleontologists K. Flerov, V. Trofimov and others.

Simultaneously with the works concerning parsnip and rhinoceros, in her individual works M.V. Pavlova described a group of camels (Pavlow, 1903). At the beginning of the 20th century the point of view on the position of the horse line of the hippopionus and palaeoteria became dominant. Lull and partly Matthew and Osborne shared the point of view of Maria Vasylivna and clearly demonstrated this in their writings on the development of equine animals in America. Unfortunate attempt was made Antonius and Abel to revive in the 20 years of the twentieth century an idea of the hypoparion origin of the horse. Although many Soviet paleontologists have joined it before, the last detailed review of this issue is not one but a few researchers (for example, V. I. Gromova – on domestic materials, Sefwe – on the American and many others who carried out their research in the 40-50s of the twentieth century), did not leave doubts as to the correctness of the conclusions about the monophyletic origin of horses and the significant specialization of the hippopionus. M. V. Pavlova convincingly proved that the latter are not just primitive ancient groups, but blind, specialized branches with nonadaptive reduction of extremities.

In general, works of M. V. Pavlova, who were devoted to ungulates, were highly praised by biologists. So, Academician O. M. Severstsov, considering them from the point of view of evolutionary morphology, pointed out that they give a lot to clarify the issues of monophyletic and polyphylactic evolution and for the question of convergence and divergence (Deforzh, 2012).

Together with the large and labor intensive work on the study of ungulates, M. V. Pavlova, starting in 1893, has launched a study of the development of proboscis. In her first scientific articles on this problem, she provided almost complete summary of all the materials known at that time about the mastodonts of the Russian Empire, and thus published articles about dinotrices, about the mammoth found near Yaroslavl, about new discoveries of mastodonts and elephants. At the same time, she constantly emphasized their stratigraphic position and significance.

However, particular importance in this series of articles about the proboscis was its fundamental work "Fossil elephants" (1899) (Pavlova, 1899.). It describes the

remnants of Quaternary elephants from different locations, and it has established a new species – the elephant Wust (Elephas Wusti). In this work, Maria Vasylivna, based on monophyletic positions, characterizes three stages of elephant development in the Quaternary period and lays the foundations for the use of their remains in the paleontological substantiation of the stratigraphy of the Quaternary deposits.

Significant contribution of M. V. Pavlova made in solving evolutionary problems. She paid the most attention to such problems: the reasons for the extinction of animals in the past geological epochs, the history of the study of the development of tertiary and post-tetan fossil mammals, the history of the development of fossil founes.

Many of the reasons for the extinction of species were written. Very many extinctions appeared and still remain a mystery: how could the forms and groups of forms that once were ordinary inhabitants of our planet disappear from the face of the earth? Thousands of researchers have met this phenomenon in their work, and it is not surprising that almost every one of them would like to find an explanation for it. Therefore, the causes of extinction of organic forms are affected in many works of nature researchers, who usually put forward certain explanations of this phenomenon. Quite often these phenomena are considered one-sided or even incorrect. Therefore M. V. Pavlova is considered to be expedient to devote a special study to the problem of extinction of species in order to comprehensively cover it on the basis of modern science.

The work of professor M. V. Pavlova was called "Causes of extinction of animals in the past geological epochs" (1924) (Pavlova, 1924). Small volume of a book by M. V. Pavlova (88 pp.) Completes the article by O. P. Pavlova "On some, little studied factors of extinction" (42 p.) (Pavlov, 1924).

The reasons for the extinction of organisms in past epochs – one of the issues on which expressed a lot of idealistic and metaphysical judgments, and many people were considered to be no explanation. Immediately emphasize M. V. Pavlova was in Darwin's position on this issue. Strongly rejecting the idea of a predetermined, limited period of existence of species, the "exhaustion of vitality" and the like, such idealistic fabrications, M. V. Pavlova saw the causes of extinction in those natural processes, which caused the evolution of the concept of Darwin. Maria Vasylivna contributed to the problem of extinction of animals in past geological epochs. She concluded that extinction depended both on external causes and on the organisms themselves, on the possibility or impossibility of adapting to constantly changing environmental conditions.

Regarding the study of M. V. Pavlova the third terrestrial mammals, it concludes that the most ancient tertiary fauna is the Sevastopol fauna of the middle Sarmatian. From the upper Sarmatian is known dinotherapy and procamulus from the outskirts of Kryvyi Rih. The meiotic layers gave an extremely large number of mammalian remains from different parts of Ukraine. Finally, from the Pontic deposits, we know several separate forms and the Russellian fauna of the middle and upper Pliocene (the

name comes from the name of the city of Russillion, France), which was described by I. P. Khomenko (Khomenko, 1915).

O. O. Borisyak refers to the ancient representatives of the gipparions to the upper middle of Sarmatian. However, he does not indicate certain differences for these forms, considering them as a kind of European hippopionus. He points only to their smaller size. But this sign is not permanent, because the forms from Kyucuron (southern France) are smaller than Sevastopol. Among the gipparions from Grebinnikov (Odesa region.) And Chobryushiv (Transnistria, Moldova), most of these sizes are Sevastopol. The variety of both the size and complexity of the enamel on the teeth varies greatly. About this says and O. O. Borisyak Maria Vasylivna believed that these data allow Sarmatian forms to be closely related and closely related to the meiotic. Regarding the Russellian forms, about which I. P. Khomenko, then this will be more distant forms that have been preserved in the Pliocene. And they belong to earlier forms, as an option with shortened limbs, and ended their existence in the Pliocene of Russia, as well as Europe as a whole.

**Conclusions**

Contribution of M. V. Pavlova's history of development of fossil founes is special. Undoubtedly, Maria Vasylivna realized that solving the problems of taxonomy and phylogeny of fossil mammals is based on the understanding of evolution as an adaptive process. That is why in her scientific works she came from the understanding that the refinement of the animal world system should be carried out taking into account morphological and adaptive features, as well as phylogenetic mutual relationships based on paleontological and modern (neontologic) data. In her scientific works, the main place occupied the morphological direction, which combines the data of classical phylogenetics with the doctrine of adaptation. Indeed, in her studies, the role of determining the essential significance of certain features in taxonomy has increased significantly, she paid considerable attention to the sum of those features that revealed morphological adaptations and probably covered the directions of evolutionary changes in organisms.

Of course, the development of these issues forms the basis of the scientific work of M. V. Pavlova. Her main scientific works are devoted to the study of mammals fauna of Eastern Europe, Siberia and the Far East. Particular attention, first of all, deserves the work of Maria Vasylivna, devoted to the gipparionous fauna, which lasted about 10 million years - from the end of the late Miocene to the middle Pliocene. She was also interested in the fauna of gazelles, deer, mastodon, ellacouries, dinotheriae, fox bears, camels, and the like.

Introduction to the scientific heritage of M. V. Pavlova convinces us that she is not only an outstanding domestic paleozoologist, but also a biologist.

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## «Нариси з історії викопних копитних» академіка М. В. Павлової як феномен у світовій палеозоологічній науці (кінець XIX – поч. XX століть)

***Анотація.*** *Мета дослідження – розкрити основні напрямки досліджень академіка М. В. Павлової у наукових працях «Нариси з історії викопних копитних» в кінці XIX на початку XX століть, показати внесок цих робіт у світову палеозоологічну науку. Наукова новизна полягає в тому, що вперше в українській історіографії комплексно досліджено життєвий шлях та наукову спадщину академіка М. В. Павлової в контексті розвитку палеозоології та*

*реконструйовано її наукову біографію; подано історію вітчизняної палеозоології крізь призму діяльності М. В. Павлової та її наукової школи; проаналізовано опубліковані та рукописні праці вченої, що дало змогу поглибити знання щодо історії вітчизняної палеозоологічної науки та її вплив на розвиток світової науки. Засновником палеонтології, як наукової дисципліни вважається видатний Жорж Кюв'є . Також творили палеонтологію та її розділ палеозоологію, такі всесвітньовідомі вчені, як Альбер Годрі, Отнієл Марш, Едвард Коп, Володимир Ковалевський, Мельхіор Неймайр, Луї Долло, Генрі Осборн та інші. До цієї плеяди вчених-палеозоологів належить і наша співвітчизниця, академік Всеукраїнської академії наук М. В. Павлова (1854-1938). Встановлено, що Марія Василівна Павлова (у дівоцтві М. В. Гортинська) – це ціла епоха в розвитку палеозоології. Адже вона – видатний фахівець із вивчення викопних ссавців, організатор та популяризатор палеозоологічної науки. Марія Василівна – палеозоолог світового рівня, знаний фахівець в наукових колах, яка була особисто знайома з багатьма видатними палеозоологами, наприклад, Альбером Годрі, який був її учителем в Сорбонні, а з Генрі Осборном вона вчилась разом в цьому ж університеті, підтримувала з ним зв'язок і листувалась все життя. Перша в Російській імперії жінка-палеонтолог, жінка-професор, жінка-академік, завдяки якій вітчизняна палеонтологія виділилась у самостійну біологічну науку і яка своїми дослідженнями заклала фундамент розвитку палеонтології (палеозоології) в Україні. Працями з історії великої кількості груп викопних копитних завершився один із циклів робіт М. В. Павлової, який показав монофілетичний розвиток більшості груп копитних, численність третинних і четвертинних фаун на території Російської імперії та загалом України. Вона засвідчила значущість досліджень викопних ссавців для стратиграфічних побудов.*

***Ключові слова:*** *палеозоологія; палеонтологія; наука; еволюція; копитні; викопні ссавці*

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## «Очерки по истории ископаемых копытных» академика М.В. Павловой как феномен в мировой палеозоологической науке (конец XIX – нач. XX века)

***Аннотация****. Цель исследования – раскрыть основные направления исследований академика М. В. Павловой в научных трудах "Очерки по истории ископаемых копытных» в конце XIX начале XX веков, показать вклад этих работ в мировую палеозоологические науку. Научная новизна заключается в том, что впервые в украинской историографии комплексно исследованы*

*жизненный путь и научное наследие академика М. В. Павловой в контексте развития палеозоологии и реконструировано ее научную биографию; подано историю отечественной палеозоологии сквозь призму деятельности М. В. Павловой и ее научной школы; проанализированы опубликованные и рукописные труды ученой, что позволило углубить знания по истории отечественной палеозоологической науки и ее влияние на развитие мировой науки. Основателем палеонтологии как научной дисциплины считается выдающийся Жорж Кювье. Также творили палеонтологию и ее раздел палеозоологию, такие всемирно известные ученые, как Альбер Годри, Отниел Марш, Эдвард Коп, Владимир Ковалевский, Мельхиор Неймайр, Луи Долло, Генри Осборн и другие. К этой плеяде ученых-палеозоологов относится и наша соотечественница, академик Всеукраинской академии наук М. В. Павлова (1854-1938). Установлено, что Мария Васильевна Павлова (в девичестве М. В. Гортынская) – это целая эпоха в развитии палеозоологии. Ведь она – выдающийся специалист по изучению ископаемых млекопитающих, организатор и популяризатор палеозоологической науки. Мария Васильевна – палеозоолог мирового уровня, известный специалист в научных кругах, которая была лично знакома со многими выдающимися палеозоологами, например, Альбером Годри, который был ее учителем в Сорбонне, а с Генри Осборном она училась вместе в этом же университете, поддерживала с ним связь и переписывалась всю жизнь. Первая в Российской империи женщина-палеонтолог, женщина-профессор, женщина-академик, благодаря которой отечественная палеонтология выделилась в самостоятельную биологическую науку и которая своими исследованиями заложила фундамент развития палеонтологии (палеозоологии) в Украине. Работами по истории большого количества групп ископаемых копытных завершился один из циклов работ М. В. Павловой, который показал монофилетическое развитие большинства групп копытных, многочисленность третичных и четвертичных фаун на территории Российской империи и в целом Украины. Она показала значимость исследований ископаемых млекопитающих для стратиграфических построений.*

***Ключевые слова:*** *палеозоология; палеонтология; наука; эволюция; копытные; ископаемые млекопитающие*

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# The value of the Naturalists Society at Kharkiv University (1869-1930) in the development of scientific research and the popularization of scientific knowledge in Ukraine

***Abstract.*** *The article reveals the importance of the Naturalists Society at Kharkiv University in the development of scientific research and the popularization of scientific knowledge in Ukraine. Social, economic, political processes that occur today in Ukraine actualize historical memory and direct historical science to comprehend the scientific processes that took place in Ukraine in ancient times. The reconstruction of scientific Ukraine in the second half of the 19th and early 20th centuries would be incomplete without an indication of the role and importance of the Naturalists Society at Kharkiv University. The author proves that the activity of the Society was versatile, large-scale, imbued with high scientific ideas and democratic tendencies. It is stated that the effectiveness of this activity was ensured by the active work of the most prominent figures of science, culture, education, namely: V. M. Arnoldi, P. I. Biletskyi, O. A. Hrosheim, O. V. Hurov, V. Ya. Danylevskyi, A. M. Krasnov, I. F. Levakovskyi, O. V. Nahornyi, O. M. Nikolskyi, Ya. V. Roll, M. M. Somov, P. P. Sushkin, V. I. Taliev, L. S. Tsenkovskyi, O. V. Chernaya, V. O. Yaroshevskyi. In particular, the role of scientists in deployment of a wide range of floristic, faunistic, geological and geographical researches as in the territory of provinces of the Kharkov educational district, and it is far beyond its limits is shown. It is emphasized that thanks to the fruitful activity of members of society considerable scientific results which promoted the development of many branches of domestic natural sciences were received. It was a company with an effective organizational structure and program of activities; it achieved outstanding results both in applied research and in the popularization of science. The Society was one of the channels for ensuring the interconnection of science and society. It acted as a certain social institute, which envisaged conducting active communication activity both within the Society and beyond. Besides, training of future generations of scientists was carried out at a high level, which testified to another feature of the Society as a social institute and a phenomenon in the system of science. The author provides little-known information about the Society, specifies evaluations and conclusions, which relate to separate parts of the scientific and popularizing activity of the Society.*

***Keywords:*** *The Naturalists Society at Kharkiv University; natural science; science; popularization; educational activities*

## Introduction

In recent years, an enhanced study of the history of national science, in particular, the history of Ukrainian natural science, has been carried out in Ukraine. This interest in the past of Ukrainian science is natural. After all, studying the cultural heritage of our country, the history of its creation by the works of Ukrainian scientists, once again convinces us how great is the contribution of our compatriots to the treasury of world science. The current generation must have a clear idea of the leading role that domestic scientists have played in the development of world science. Studying the history of scientific thought allows us to understand more deeply the genesis of important scientific discoveries, promotes the upbringing of patriotism and develops a sense of pride in one's homeland.

150 years have passed since the beginning of the activity of one of the oldest groups of voluntary scientific associations of our country – societies of nature researchers at universities. These societies, which unfortunately do not exist in Ukraine today, were created on the initiative of the First Congress of Russian Naturalists in December 1867 – January 1868. The need for these new forms of organization of scientists was prompted to bring science closer to society. As experience has shown, the founding of societies of nature researchers at the largest domestic universities was one of the greatest achievements of the First Congress of Russian natural scientists (Gelfenbeyn, 1965). Societies have become a true consolidating force of scientists in the development of science. Well-known and little-known scientists – botanists, zoologists, physiologists, geologists, geographers – worked actively among them. The territory of our country, unique in the diversity of natural conditions, made it possible for researchers to study the amazing organic and inorganic nature.

Along with colossal scientific work, the Society carried out extensive cultural and educational activities: conducted excursions, organized public lectures, prepared special courses in science for schools and colleges, printed popular science works, participated in international congresses, etc. The members of the Society themselves organized a huge library. The scientists who made a significant contribution to the popularization of science were O. S. Brio, V. Ya. Danylevskyi, A. M. Krasnov, O. M. Nikolskyi, L. V. Reinhard, V. I. Taliev, L. S. Tsenkovskyi, and others.

The purpose of the article is to substantiate the importance of the Naturalists Society at Kharkiv University (1869-1930) in the development of scientific research and the popularization of scientific knowledge in Ukraine.

## Research methods

The paper uses general scientific and special historical research methods. Among theoretical - historical and theoretical analysis of domestic and foreign literary and archival sources; study and generalization of scientific literature,

legislative documents of the relevant period; analysis, synthesis, comparison, method of parallels, generalization and systematization of actual material. Among the special historical methods there is the historical and retrospective method, which made it possible to trace the patterns and specifics of the historical reality of that time, as well as to characterize the value of the Naturalists Society at Kharkiv University in the development of scientific research and the popularization of scientific knowledge in Ukraine; a diachronic method by which qualitative changes and achievements of members of the Society in various fields of natural science were investigated; comparative-historical and historical-scientific methods made it possible to find out the scientific and socio-cultural value of the results of the activity of the Society (Pylypchuk & Strelko, 2018).

**Results and Discussion**

The organization of scientific researches in societies of researchers of nature stimulated scientific search, promoted the development of the creative initiative of scientists. This group of societies, as noted in the literature, has made a huge contribution to the development of national and world science (Materials on the organization and operation of scientific natural societies and research institutions of Ukraine, 1921-1925, p. 92). Acquaintance with the literature convinces us that the history of societies of researchers of nature at pre-revolutionary universities of Russia and Ukraine has been studied very insufficiently. First of all, the mechanism of their amazing scientific productivity has not been properly identified. In general, academic societies at universities have always played a prominent role in carrying out educational and research functions and shaping the scientific worldview of young people.

M. P. Kononenko extremely aptly noted the role played by natural-scientific societies in the development of civil society. In particular, he noted: «Historically and pedagogically, the natural societies of Ukraine have created a socially significant and interesting, largely original, domestic teaching experience. The study of pedagogical theory and practice of natural societies of Ukraine, scientific works of their members convincingly shows that their achievement is often a high example of a harmonious combination of scientific and natural ideas, approaches in the educational process and formation of civil society. Members of natural societies of Ukraine paid considerable attention to the awakening and formation of different inclinations, abilities in school and student youth. Particular attention was paid to identifying and developing the talents of adolescents and young people (Kononenko, 2004, p. 99).

Analyzing the phenomenon of the Naturalists Society at Kharkiv University, it is important to pay attention to the fact that it acted not only as a collective subject of scientific activity which task was to produce, reproduce and transmit scientific knowledge but also to the remarkable socio-cultural significance of its activity. In fact, researchers united by a common interest in a free society, not regulated by class, property, educational boundaries, have played a leading role not only in the scientific but also in the cultural and social development of our country. The axiological

approach to understanding natural science thought allowed us not only to state historical facts related to the activity of the Society, the creative achievements of its members, but also to reflect the deep moral meaning of their discoveries, their scientific works, their impact on future generations.

The second half of the XIX – the first third of the XX century – is a relatively short period in the life of our country; it is full of innovations of the scientific and organizational plan which contributed not only to the creation of the developed scientific community but also stimulated the most complete manifestation of the characteristic features of the national scientist among its members. The activity of scientists of this period was an important link between the system of value orientations adopted by the intellectual labour in the second half of the XIX century and the social type of native naturalist, which was formed on the edge of the XX century (Demuz, 2014). At this difficult time, the scientific elite carried out responsible tasks not only for the development of the system of scientific knowledge but also for the creation of its scientific community. Many of these scholars belonged to «diverse elite». Some natural scientists from their early years, overcoming considerable difficulties, formed their destiny. Their hard work, creative talent, unselfish attitude to science gave them a real opportunity to occupy a worthy place in it. All of them, without exaggeration, were committed to science and sought to make a significant contribution to their country's involvement in science. They have practically always played the role of enlighteners in society, teachers who have shaped the scientific worldview of their students. The main means of strengthening the social position of domestic scientists was self-organization, that is, informal ways of association and communication (Chesnova & Fando, 2008). This was one of the important motives of conscious orientation on the cultivation of collective ways of research work, which was manifested in the development of scientific schools and societies. Such informal formations are characteristic of the Institute of Science irrespective of the socio-cultural atmosphere that gives rise to them. However, domestic scientists saw a little more in organizing informal associations, namely, the creation of centres of collective creativity, scientific continuity, intellectual freedom.

At that time, a galaxy of outstanding scientists worked in Kharkiv-zoologists – O. V. Chernai, P. P. Sushkin, O. M. Nikolskyi; botanists V. M. Arnoldi, O. A. Hrosheim, A. M. Krasnov, Ya. V. Roll, V. I. Taliev, L. S. Tsenkovskyi, L. A. Shkorbatov; physiologists V. Ya. Danylevskyi, O. V. Nahornyi; geologists N. D. Borysiak, O. S. Brio, O. V. Hurov, I. F. Levakovskyi, P. P. Piatnytskyi; geographers M. Ye. Krendovskyi, Yu. I. Morozov. And they were all honorary and full members of the Naturalists Society at Kharkiv University (Korobchenko, 2016). These scientists took an active part in the activities of the Society, through their work they raised national science to a much higher level. They have carried out a large amount of scientific research in the field of floristics, faunistics, botanical and zoological systematics, plant and animal morphology and physiology, as well as geology, mineralogy, and geography.

The Society was the coordinator of the scientific activity of scientists. Natural scientists worked out theoretical and production problems of natural science, they played a special role in the spiritual and social life of Ukraine. The members of the Society held liberal positions, supported advanced students and advocated the freedom of scientific creativity. The relations of scientists with the authorities were not easy. In the second half of the XIX century, the tendency of the ambiguity of the state's stance on science intensified: on the one hand, it was recognized as a source of economic and military power, and on the other, it was suspicious of its democratic traditions and corporate spirit, which was based on Western European culture. The members of the Society play a leading role in the creation of a special form of scientific activity - collective scientific creativity. The special place of the Society in the development of national science is due to the fact that its research activity in comparison with the academic science (Academy of Sciences, universities, institutions of higher education) was closer to the needs of the national economy, it was more fundamental and diverse. The Society started to form and develop a number of the most important directions and problems that are successfully developing today.

The formation of the Society as a social structure was determined by the objective process of the historical development in the second half of the XIX century. At that time, the demand for basic research and skilled personnel increased significantly. While the need for personnel was mainly met due to graduates of Kharkiv University and other institutions of higher education in the country, the need for sound recommendations was met due to high professionalism, high organization of scientific work, socio-cultural and democratic community inherent in the society. The Society educated not narrow specialists, but naturalists with broad and thorough training in the main branches of natural science – biology, geology, geography, etc.

Referring to the initial period of activity of the Naturalists Society at Kharkiv University, you can see what a great contribution to the development of natural science was made by scientists under the auspices of the Society. One of the priority tasks, according to the Charter of the Society, was «conducting natural history studies in zoology, botany, mineralogy, geology, paleontology in Russia, and counties adjacent to the provinces of Kharkiv educational district; collecting and assembling systematic collections; publication of scientific works; dissemination of natural history in Russia». In the first year of its existence, the Society has equipped zoological expeditions for exploring Kharkiv province (P. T. Stepanov, O. F. Maslovskyi). Considerable collections of animals and plants were collected, information on the fauna and flora of the Siverskyi Donets was received, important geological observations were made. The company also directed its expeditions to study the minerals of the region (Polovka & Polovka, 2017). In 1869 H. F. Shperk, L. V. Reinhard and M. V. Sorokin made a trip to the outskirts of Belgorod in order to study the cryptogamous flora, visited for the same purpose the outskirts of Zmiyev, lakes of Sloviansk and the outskirts of Sviatohorsk Monastery ( now Mountain Artem). With the emergence of the Society, a period of systematic exploration of the

Azov and Black Seas also began. Rich collections (which exist today) were gathered in expeditions and transferred to the Zootomical, Zoological, Botanical and Mineralogical Offices of Kharkiv University (91 collections in total).

With all the autonomy and independence of scientific societies from the administration of universities, their existence at the main centers of public education had enormous content. Thus, the Society's library was accessible to its members who were not full-time employees of the University. At the same time, the library of the Society itself was stored at the departments at which the relevant branches of the Society worked (Bagalej & Osipov, 1911). Collections gathered by expeditions organized by the Society were received at the departments and offices of the University. Meetings of the Society, which were lively held at the university and were followed by discussions, were accessible not only to those who were relevant to the university but also to anyone interested in a particular field of science. Thus, in all the years of its activity, the Society played an important role in the consolidation of scientific forces. The attraction to the Society was explained, on the one hand, by the desire of scientists to join their forces in order to spread the front of scientific research, to obtain more scientific data and more valuable scientific materials, and on the other hand, by those privileges and advantages in conducting scientific research, which gave the Society. Although it did not have very significant financial resources, it still allowed its members to occasionally go on scientific expeditions and trips, print scientific articles and notes in their publications, as well as the right to scientific hunting in any season of the year, etc. (Ustav Obshhestva ispytatelej prirody pri Imperatorskom Kharkovskom universitete, 1869). Members of the Society were scientists already known for their scientific works, as well as very young naturalists, among whom there were many students of the Department of Natural Sciences of the University.

It should be noted that the second half of the XIX century in biology was characterized by profound methodological shifts. It was a period of struggle for Darwinism, for the materialistic theory of the development of the organic world, against the ideas of creationism (Pavlenko, Ruda, Khorosheva & Khramov, 2001). In this struggle, the Society has shown itself as no other society in such a plan. It is here that we see strong supporters of Darwinism (O. M. Nikolskyi, P. P. Sushkin, L. S. Tsenkovskyi, O. M. Krasnov, V. I. Taliev) and even more aggressive supporters of anti-Darwinism (O. F. Brandt, O. F. Maslovskyi, Ye. O. Shults). The democratic and materialistic traditions cultivated in the Society, as well as the progressive views, served as an incentive for the research and education of young scientists. Through their scientific and social activities, natural scientists created a certain moral climate, a spiritual atmosphere in which the lives of more than one generation of scientists were flowing. Spiritual values were preferred in the Society, and the interests of science were paramount.

Scientists were interested not only in pure science. The Society has played an essential role in raising interest in natural science among the general population of Ukraine. Through their educational activities, the Society's naturalists have raised the

level of education and spirituality of the people. The idea of direct relentless service to the people deeply penetrated the sphere of creative activity of the members of the Society, inspired them to find ways of introducing scientific ideas into the national consciousness. In this enlightenment, leading scholars saw a way of expressing their social position. The enormous cultural and educational role of the Society was in the promotion of natural science knowledge through the organization of public lectures and the publication of popular science literature. The Society successfully conducted scientific excursions and expeditions (within Russia, Ukraine and abroad), created exhibitions and museums, established awards, established a biological station, maintained active scientific links with other scientific societies and organizations. It is hard to deny that it is through the description of nature, popularization of natural science and one's language the patriotic education of a person is carried out, educational tasks are solved, love and respect for one's homeland and people are instilled.

One of the important forms of cultural and educational activity and at the same time engaging in experimental work of children and young people were numerous excursions, which gave a lot of material for its further scientific processing. The Society's research and excursion projects facilitated the organization of exhibitions and the replenishment of its own museum. The merit of the Society was also his active participation in the decoration of the provincial museums of history. Getting acquainted with interesting exhibits caused the desire of the general public to get to know the history of their land even more deeply, to study places of history and culture directly on the ground. This work laid the foundations for the further development of the tourist-excursion business as a social phenomenon. The members of the Society widely implemented the excursion method in order to study the problems of the history of Ukraine, local history, natural science, nature conservation. This greatly contributed to the development of Ukrainian culture, the formation of the national consciousness of the people (Korobchenko, 2014).

In the 20s of the XX century, the popularization activity of the Society significantly activated. To this end, in 1922, a scientific popular commission was established under the Kharkiv Naturalists Society. The main task of the Commission was to disseminate natural and historical knowledge among the broad circles, as well as to involve them in scientific work and to promote the objectives of the Society. The special task was to monitor the achievements of modern science and to familiarize them with the members of the Society. To meet these objectives, the Commission held special meetings at which reports and lectures were heard, provided exhibitions, excursions and expeditions of a scientific and popular nature. The commission consisted of full members and associate members. All full members of the Society could become active members of the Commission. All interested employees of the Society, as well as all those who were interested in science, could be associate members. The latter was elected, on the recommendation of two full members of the Commission, by voting. The Bureau of the Commission consisted of a chairman and a secretary, who were elected from among the full members of the

Commission for the period of one year. The Commission convened regular and general meetings. At the regular meetings scientific reports, abstracts, literature reviews on various issues of natural science were read and discussed. At the general meetings Presidium election took place, budget and report of the Commission, business trips and appropriations were approved. All questions were resolved by a simple majority of the present full members of the Commission. General meetings were considered valid if at least half of the members residing in Kharkiv were present. The Commission used the seal of the Society. Regular meetings were considered valid with any number of those who gathered. The Commission was required to provide the Society with an annual report on its activities and a work plan for approval by the general meeting of the Society. The Commission's funds consisted of membership dues, government subsidies, lectures and courses, exhibitions and donations. Commission organized courses on techniques of excursion business.

Although it has not been possible to organize public lectures for the Naturalists Society at Kharkiv University for a long time, natural scientists who understood the crucial importance of promoting scientific knowledge among the general public, found and implemented various ways and opportunities for organizing this.

The Donetsk Biological Station played an extremely important role in cultural and educational work. Thus, in 1927 a museum of local nature was organized at the station, which contained interesting collections of fish, amphibians, reptiles, birds, mammals, insects (a total of 70 species − 382 specimens). This museum was widely used for demonstrations. In addition to scientific work, a workshop was organized on the basis of the biostation and educational excursions were conducted for students of higher education institutions of Kharkiv.

In the early XX century, progressive members of the Society turned to the problem of nature conservation. Such scientists as V. G. Averin, S. I. Medvedev, V. I. Taliev, O. A. Yanata already began to realize the importance of nature conservation. Today, we clearly understand that nature and the nationwide struggle for its preservation and cleanliness are a crucial component of our culture. The experience of previous generations of scientists is extremely relevant today because even then they offered methods by which it was possible to form a correct system of values in the relationship between man and nature. People from all over Ukraine and Russia, sought guidance from the Society on how to study natural history objects and phenomena, shared their observations on nature, disinterestedly sent natural history objects and entire collections related to the fields of mineralogy, zoology, botany, palaeontology. These collections were scientifically processed by the scientists of the Society, and the results of this work were printed, which contributed to the accumulation of valuable material for the knowledge of nature.

The merit of the Naturalists Society at Kharkiv University was its active participation in the decoration of provincial museums of history. Due to extensive publishing activity, each of the members of the Society was allowed to publish their research. The Society published «Trudy Obshchestva Ispytateley Prirody pri

Khar'kovskom Universitete» (Proceedings of the Society of Nature Examiners at Kharkiv University), as well as «Protokoly zasedanii Obshchestva ispytatelei prirody pri Imperatorskom Khar'kovskom universitete» (Minutes of the meetings of the Society of Nature Investigators at the Imperial Kharkiv University) (Ustav Obshhestva ispytatelej prirody pri Imperatorskom Kharkovskom universitete, 1869). «Trudy» was a highly professional publication of the works of natural scientists of the Society, which contained great material for the formation of scientific concepts. The results of the research were presented by the members of the Society at the discretion of their colleagues and were published only after discussion at the meetings. The high scientific value of the published works was not in doubt, as each of them was previously discussed and a corresponding resolution was passed, which approved after the closed ballot. Discussion of progress and results was extremely important, as it allowed us to formulate common points of view, approaches, positions of participants. Each participant had the right for their opinion, had the right to express and defend it. Any suppression of discussion was strictly prohibited.

**Conclusions**

Thus, the Naturalists Society at Kharkiv University was an active public body, whose purpose was to comprehensively promote the development of natural science in our country. In the way of progress of science, voluntary scientific societies in general and the Naturalists Society at Kharkiv University, in particular, were the centers of crystallization, those centers of knowledge, the flame in which was maintained by the collective mind, multiplied by enthusiasm, encyclopedic education and high civic position of the scientists who led these associations. The high scientific authority of the Society relied on the authority of knowledge and logic of belief. Its successes were achieved through enthusiasm, free creative initiative, patriotism, deep scientific interest in the tasks of all its members without exception. The study of the practical and scientific activity of the Society is still relevant today because it extends our knowledge about the nature and scope of social and scientific life of our Motherland. For 60 years, the Society has symbolized the intellectual strength of our nation, its contribution to world civilization. In terms of autocracy, the Society was the bearer of leading scientific ideas, contributing to the development of science and the economy through its activities. In the Soviet times, it remained a democratic association of creatively gifted specialists, people from different classes. The Society was famous for its traditional multilateral links with national and international scientific schools and individual scientists. The close scientific and personal communication of the Society's natural scientists with European and American scientists has given the Society high scientific authority.

In fact, the Society reflected in its activities all the conceptual statuses of science. It was aimed at producing new knowledge. The obtained knowledge was transmitted not only to a limited number of representatives of one or another scientific area but also to the whole scientific community, society as a whole. The Society has become one of the main channels for ensuring the interconnection of

science and society. It acted as a certain social institute, which envisaged conducting active communication activity both within the Society and beyond. In addition, the training of future generations of scientists was carried out at a high level, which testified to another feature of the Society as a social institute and a unique phenomenon in the system of contemporary science.

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# Значення Товариства дослідників природи при Харківському університеті (1869-1930) в розвитку наукових досліджень і популяризації наукових знань в Україні

***Анотація.*** *В статті розкривається значення Товариства дослідників природи при Харківському університеті в розвитку наукових досліджень і популяризації наукових знань в Україні. Соціальні, економічні, політичні процеси, які відбуваються сьогодні в Україні актуалізують історичну пам'ять і спрямовують історичну науку до осмислення наукових процесів, які розгорталися на теренах України в минулі часи. Реконструкція наукового життя в Україні другої половини XIX - початку XX ст. була б неповною без окреслення ролі та значення товариства дослідників природи при Харківському університеті. Авторка доводить, що діяльність Товариства була багатогранною, широкомасштабною, пронизаною високими науковими ідеями і демократичними тенденціями. Вказано, що ефективність цієї діяльності забезпечувалась активною працею найвизначніших діячів науки, культури, освіти, а саме: В. М. Арнольді, П. І. Білецького, О. А. Гросгейма, О. В. Гурова, В. Я. Данилевського, А. М. Краснова, І. Ф. Леваковського, О. В. Нагорного, О. М. Нікольського, Я. В. Ролла, М. М. Сомова, П. П. Сушкіна, В. І. Талієва, Л. С. Ценковського, О. В. Черная, В. О. Ярошевського. Зокрема, висвітлюється роль вчених у розгортанні широкого спектру флористичних, фауністичних, геологічних і географічних досліджень, як на території губерній Харківського навчального округу, так і далеко за його межами. Підкреслюється, що завдяки плідній діяльності членів товариства були отримані значні наукові результати, які сприяли розвитку багатьох галузей вітчизняного природознавства. Товариство було організацією з ефективною організаційною структурою і програмою діяльності, досягло непересічних результатів як у дослідженнях прикладного характеру, а також у популяризації науки. Товариство було одним із каналів забезпечення взаємозв'язку науки і суспільства. Воно виступало як певний соціальний інститут, який передбачав ведення активної комунікаційної діяльності як у середині Товариства, так і за його межами. Крім того, на високому рівні здійснювалась підготовка майбутніх поколінь учених, що свідчило про ще одну рису Товариства як соціального інституту й феномену в системі науки. Авторка наводить маловідому інформацію про Товариство, уточнює і конкретизує оцінки і висновки, які стосуються окремих сторін наукової і популяризаційної діяльності Товариства.*

***Ключові слова:*** *Товариство дослідників природи при Харківському університеті; природознавство; наука; популяризація; просвітницька діяльність*

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## Значение Общества испытателей природы при Харьковском университете (1869-1930) в развитии научных исследований и популяризации научных знаний в Украине

***Аннотация.*** *В статье раскрывается значение Общества испытателей природы при Харьковском университете в развитии научных исследований и популяризации научных знаний в Украине. Социальные, экономические, политические процессы, которые происходят сегодня в Украине актуализируют историческую память и направляют историческую науку на осмысление научных процессов, которые происходили на Украине в прошлое время. Реконструкция научной жизни в Украине второй половины 19 – начала 20 века была бы неполной без указания роли и значения общества испытателей природы при Харьковском университете. Автор доказывает, что деятельность Общества была многогранной, широкомасштабной, пронизанной высокими научными идеями и демократическими тенденциями. Указано, что эффективность этой деятельности обеспечивалась активным участием выдающихся деятелей науки, культуры, образования, а именно: В. М. Арнольди, П. И. Белецкого, А. А. Гроссгейма, А. В. Гурова, В. Я. Данилевского, А. Н. Краснова, И. Ф. Леваковского, О. В. Нагорного, А. Н. Никольского, Я. В. Ролла, Н. Н. Сомова, П. П. Сушкина, В. И. Талиева, Л. С. Ценковского, А. В. Черная, В. А. Ярошевского. В частности, показана роль ученых в разворачивании широкого спектра флористических, фаунистических, геологических и географических исследований, как на территории губерний Харьковского учебного округа, так и далеко за его пределами. Подчеркивается, что благодаря плодотворной деятельности членов общества были получены значительные научные результаты, которые способствовали развитию многих отраслей отечественного естествознания. Общество было организацией с эффективной организационной структурой и программой деятельности, достигло весомых результатов в исследованиях прикладного характера, а также в популяризации науки. Общество было одним из каналов обеспечения взаимосвязи между наукой и обществом. Оно выступало как некий социальный институт, который предусматривал ведение активной коммуникационной деятельности как в самом Обществе, так и за его пределами. Кроме того, на высоком уровне осуществлялась подготовка*

*будующих поколений ученых, что свидетельствовало о еще одной характеристике Общества как социального института и феномена в системе науки. Автор подает малоизвестную информацию об Обществе, уточняет и конкретизирует оценки и выводы, которые касаются отдельных сторон научной и популяризационной деятельности Общества.*

***Ключевые слова:*** *Общество испытателей природы при Харьковском университете; естествознание; наука; популяризация; просветительская деятельность*

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# Legislative activities of the Kyiv Law society in the field of railway transport

***Abstract.*** *The research of the scientific heritage of the Kyiv Law Society, which worked at the Kyiv University of St. Vladimir in the second half of the XIX and early XX centuries, is of current relevance within the framework of civil society development in Ukraine. The variety of its scientific directions speaks of the tireless desire of the members of the Society to improve the national legislation, to solve a number of legal problems and to promote the development of legal science in the Ukrainian lands. This article investigates the problems in the field of railway transport to have been actively discussed at the meetings of the Kyiv Law Society. The main steps in the creation of a unified railway legislation in the Russian Empire in the second half of the XX century, which was mandatory for all railways in the country, are outlined. The role of the Commission for the Study of Railways in Russia of E. T. Baranov, which was created to study the state of railways in the country, has been considered. It is shown that the Commission consisted of leading scientists and public figures of the country – A. F. Koni, S. Yu. Vitte, A.A. Vendrykh, M.M. Annienkov and others. It has been stated that the main purpose of the Commission's activity was to collect the necessary materials from foreign and domestic railway and judicial practice, which could be studied as much as possible with the participation of representatives of science, trade, military affairs and industry, with the purpose of creating the General Statute of Railways of the Russian Empire, which became the first codified source of law precisely in the railway business. It has been shown how the KLS took part in this process. The speeches of individual scientists such as O. F. Kistiakivskyi, D. I. Pikhno, M. Ye. Krainskyi, A. H. Dolzhanskyi, O. F. Kvachevskyi who spoke on the problems of railway jurisprudence, put forward their proposals, discussed the possibilities of appropriate changes in the development of the railway industry and held discussions at the meetings of the Society have been analyzed. In addition, the history on the creation of the General Statute of Railways, its content and significance for the railway business in the Russian Empire, which became the first step in the formation of a unified legal field on the entire network of national railways, have been revealed.*

***Keywords:*** *Kyiv Law Society; railways; the legal component of rail transport; the Uniformed Statute of Russian railways*

## Introduction

The active development of capitalism in the Russian Empire in the second half of the XIX century led to the rapid expansion of the rail network throughout the country, which was built by both the state and private companies, but mainly with state borrowing. Every year, new railways were created, each operating under its own rules. All this led to the fact that in the mid-70's of the XIX century there was an urgent need to create a unified country-wide railway legislation that would set uniform legal rules for the operation of railway transport (Murav'eva, 2017).

The Kyiv Law Society (hereinafter referred to as KLS), which was established in 1876 at St. Vladimir's University of Kyiv, has repeatedly engaged in law-making in the course of its activity, since its ranks included leading legal scholars, representatives of judicial institutions, well-known lawyers, judges, jurists who created a stable center of Ukrainian legal thought in Kyiv in the second half of the nineteenth century.

## Methods of research

In this scientific study, the methodological basis of the study is the historical method of research, based on the study of the emergence, formation, and development of objects in chronological sequence, which achieves an in-depth understanding of the essence of the problem. In addition, a chronological method was used, which provides for the presentation of historical material in chronological order at all stages of the development of a historical phenomenon, the methods of bibliographic and source analysis used in the search, systematization, and processing of primary information. The principles of historical validity, objectivity, consistency, and complexity have also been applied (Pylypchuk, 2019).

## Results and discussions

In April 1876, the Government of the Russian Empire initiated the issue on the state of the railroad in the country. For this purpose, the Commission for the Study of Railways in Russia was set up under the chairmanship of Count Eduard Baranov, which included leading scientists and political figures of the time. This is a well-known lawyer, public official and court speaker, a member of Kyiv Law Society A. F. Koni, and future Minister of Railways S. Yu. Vitte, and a military engineer, a member of the main Railway Inspection A. A. Vendrykh, and the Chief Clerk of the Commission M. M. Annienkov who later built the Trans-Caspian Railway (Guansyan, 2016).

The Commission appealed to the law firms of the country, including the KLS, to collect the necessary materials on foreign and domestic railway and judicial practice, which could be maximally studied with the participation of representatives of science, trade, military affairs, and industry. And also it asked to present a number of problematic issues in the railway business, which at the time did not have a solution.

This issue was initiated in order to improve the national legislation, namely the introduction of separate rules for regulating legal relations in rail transport.

The chairman of KLS professor O. F. Kistiakivskyi suggested to the members of the Society to accept this proposal and take up the solution of this case. At the meetings of the KLS, many issues were discussed on this problem. Some of these have been described in detail in the Company's minutes. For example, at the meeting of September 15, 1879, A. F. Kistiakivsky made several provisions that he believed required consideration for the introduction of common rules and railway legislation.

First, he proposed to introduce a rule that the holder of a 14-day coupon ticket would be entitled to interrupt and resume, during that time, their journey at any station on the travel line of a train.

It turns out that in the second half of the XIX century there were 14-day coupon tickets, and the passenger was allowed to leave at any station that was included in the coupon book during that time. The problem was that the passenger could not get off at any station, but only on the main ones included in the coupon book. And this was a problem for passengers, because in the second half of the XIX century routes were not as developed as they are now, and every kilometer for the passenger was a big problem. If the passenger was traveling from Kyiv to St. Petersburg, the coupon book contained the stations Nizhyn, Konotop, Vorozhba, etc. And the passenger could not go to Brovary to visit his relatives, he had to go to Nizhyn and then to get to Brovary by himself. The scientist thought that it was very inconvenient for the passengers and suggested to introduce the rule.

Secondly, Oleksandr Fedorovich offered to introduce roundtrip tickets. The scientist noted that it was practiced all over the world between 2-3 stations, between which they traveled back and forth for 2–3 days. In the early 80's of the XIX century, it was very important for trips to the suburbs, where the people went to have a rest on weekends, holidays and spring and summer days. The scientist believed that such a ticket would be a real gift for the public who cherished every minute of their vacation.

Thirdly, O. F. Kistiakivsky stressed the need to introduce reduced fares for members of scientific congresses and business trips. In particular, he noted that the government recognized the validity of these petitions, while the railway companies with special understanding gave the right of free access to the railroad to judicial investigators, magistrates, police officers, and no longer to the scientists who deserved it more.

*«The basis for such a decline was to recognize the great cultural power of science to the people, the science that invented railroads, telegraphs, and electric lighting, and made great discoveries in the field of improving society.*

*Thus, because the maintenance of the cultural importance of science is a permanent, normal duty of any state if it wants to be cultured, it would be desirable to establish a mandatory rule once and for all for railway societies to impose a fare for members of congresses, conventions and scientific business trips to the*

*destination»* (Protokol zasedaniya № 9 Kievskogo yuridicheskogo obshchestva ot 15 sentyabrya 1879 g., 1880).

The same concerned the cost of tickets to all-Russian industrial and technical exhibitions for working-class people who were entitled to such a trip by official institutions.

Fourth, O. F. Kistiakivskyi proposed the introduction of so-called long-term county tickets, which were also actively practiced in foreign countries and allowed a large number of the population to travel long distances. Moreover, the cost of such tickets was significantly lower than the cost of tickets for individual distances of a given trip. The scientist believed that active trips of the population to remote regions of the country could significantly increase the economic and cultural status of the country.

Of all the proposals of O. F Kistiakivsky, a discussion was only caused by the first. Most colleagues of the scientist believed that this situation was not problematic, it was only necessary to add in the coupon book additional pages for all intermediate stations, as Professor V. H. Demchenko thought, or to leave additional wagons at the stations just in case, as A. G. Dolzhansky noted.

Professor D. I. Pikhno drew the attention of those present that this proposal could cause technical and economic problems. In particular, he noted that each train was assigned an appropriate number of wagons according to the number of passengers. In the event of a sudden increase in the number of passengers, an extra wagon would have to be hitched, which could only be done at large stations. The small stations could only issue as many tickets as there were seats, which could make it difficult for anyone who travels. M. Ye. Krainskyi noted to this that there were few passengers on direct tickets, so the technical side of this proposal could not be a problem (F-rg, 1879).

There were also pathetical statements of those present who clearly did not understand the peculiarities of the railway business. For example, A. T Dolzhanskyi noted that railways exist for society, so the convenience of the public should be above technical difficulties. If there are direct tickets that entitle them to leave at any intermediate station, then the technical difficulties of the railway could not violate the rights of passengers.

D. I. Pikhno responded that railways could not be regarded as a private institution only because the treasury was interested in their work, which guaranteed the railways a proper profit. Therefore, it was impossible to afford unnecessary expenses without affecting the treasury. Extra carriages would have a corresponding cost because passenger traffic was always very uneven.

O. A. Kvachevskyi noted that Dmitry Ivanovich's objections had a special character that could not be ignored because it was of general importance in relation to all railway issues. When a passenger claimed any violated right, the railway department as a rule stated inconvenience or disadvantage of the passenger's requirements for control, not taking into account the right. It is obvious that the point

of view was not the answer to the question, after all, the question of law can only be answered legally.

Thus, the remark of Kistiakivsky had a purely legal basis, while D. I. Pikhno responded not to the denial of the passenger's right, but to the reasoning of the technical disadvantage of exercising that right for the railways.

The right, according to the scientist, can not be perceived through the prism of the benefits of the person who has to exercise this right. But there is a system and, in this case, the implementation of the right is not possible without taking into account the technical side of the case, because whatever rights are not given to the population, they will not be able to be realized if the technological process of transportation by rail.

M. Ye. Krainskyi noted that those small operating surcharges offered by Oleksandr Fedorovich had been negligible compared to the amounts that disappeared on the railways under the guise of operating costs. And that it is sufficient to establish strict control over the railway industry in order to obtain the necessary savings in operation, which would give passengers the necessary facilities during transportation.

As a result of the discussion, O. F. Kistiakovskyi noted that the number of passengers interrupting and resuming their journey was very small, so it could not significantly affect the technical side of transportation (Protokol zasedaniya № 9 Kievskogo yuridicheskogo obshchestva ot 15 sentyabrya 1879 g., 1880).

The Commission had worked for 4 years. As a result, it was determined that the work of domestic railways was unsatisfactory and the money spent on its construction did not justify itself. This was primarily due to the fact that some railways were constructed without economic consideration, with poor bandwidth and poor maintenance.

The Commission determined that the lack of single railway legislation was the main reason for this situation. This is how the idea of creating a Statute of the Russian Railways was born, which was perceived negatively in the Ministry of Railways. Officials chaired by Minister of Transport K. M. Posiet in any way hindered the creation of the Statute because they feared to expose their abuses and troubles. But it did not work (Gross, 2011).

The first general statute of the Russian railways was signed by Emperor Alexander III on June 12, 1885. From that moment on, the railways of the country introduced a direct non-overloading route which, of course, significantly accelerated the movement of carriages. The statute consisted of three sections: «Section on the Carriage of Passengers and Cargoes by Railways», «Section on Rules on Jurisdiction and Limitation of Railway Claims on the Procedure for Enforcement of Decisions on Railway Claims» and «Section on Police Railway Rules», also it regulated the activity of the transport administration, transportation of people and goods. In this regard, the Ministry of Railways established special bodies for the operational regulation and management of operational work, which was an important step in the process of improving the national railways. As well, the Council on Railway affairs was established under the Ministry, which became its advisory body and supervised

the work of various institutions for the construction, maintenance, and operation of railways of various forms of ownership.

The General Statute of the Russian Railways became the first codified source of law in the railway business. It was a legal act binding on all railways of the country, which was the first step in forming a single legal field on the entire network of domestic railways (Klimov, 2017).

## Conclusion

Thus, in the activity of railway transport in the Russian Empire, through the legal companies of the country, in particular KLS, state regulation and control was established, which was reflected in the work of the railway administration. This document became the basis for further legislation on the subject, in particular for the General Statute of the USSR Railways (1920). It should be noted that the main paragraphs of this statute are still in use in the railway industry and are the main source of the current statute of the Ukrainian railways.

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## Правотворча діяльність Київського юридичного товариства в галузі залізничного транспорту

***Анотація.*** *Дослідження наукової спадщини Київського юридичного товариства, яке працювало в Київському університеті Св. Володимира у другій половині XIX – на початку XX ст., на сьогодні носить актуальний характер рамках розвитку громадянського суспільства в Україні. Різноманітність його наукових напрямків говорить про невтомне бажання членів Товариства вдосконалити вітчизняне законодавство, вирішити низку юридичних проблем і сприяти розвиткові юридичної науки на українських землях. У даній статті досліджено, які проблеми в галузі залізничного транспорту активно розглядалися на засіданнях Київського юридичного товариства. Висвітлено основні кроки у створенні єдиного залізничного законодавства в Російській імперії в другій половині XIX ст., яке було обов'язковим до виконання усіма залізницями країни. Розглянуто роль Комісії з вивчення залізничної справи в Росії Е. Т. Баранова, яку було створено з метою вивчення питання про стан залізничної справи в країні. Показано, що до складу Комісії входили провідні вчені і громадські діячі країни – А. Ф. Коні, С.Ю. Вітте, А.А. Вендрих, М.М. Аннєнков та інші. Зазначено, що основною метою діяльності Комісії було зібрання необхідних матеріалів з іноземної і вітчизняної залізничної і судової практики, які можна було б максимально вивчити за участі представників науки, торгівлі, військової справи і промисловості з метою створення Загального статуту залізниць Російської імперії, який став першим кодифікованим джерелом права саме у залізничній справі. Відображено, як КЮТ приймало участь у даному процесі. Проаналізовано виступи окремих вчених на засіданнях Товариства – О. Ф. Кістяківського, Д. І. Піхна, М. Є. Українського, А. Г. Должанського, О. Ф. Квачевського з проблем залізничної судової практики, в яких вони вносили свої пропозиції, обговорювали можливості відповідних змін у у рамках розвитку залізничної галузі і вели дискусії. Крім того, розкрито історію створення Загального статуту залізниць, його зміст і значення для залізничної справи Російської імперії, що стало першим кроком у формуванні єдиного правового поля на усій мережі вітчизняних залізниць.*

***Ключові слова:*** *Київське юридичне товариство; залізниці; юридична компонента залізничного транспорту; Загальний статут російських залізниць*

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# Правотворческая деятельность Киевского юридического общества в области железнодорожного транспорта

***Аннотация.*** *Исследование научного наследия Киевского юридического общества, которое работало в Киевском университете Св. Владимира во второй половине XIX - начале XX в., сегодня носит актуальный характер в рамках развития гражданского общества в Украине. Разнообразие его научных направлений говорит о неутомимом желании членов Общества усовершенствовать отечественное законодательство, решить ряд юридических проблем и способствовать развитию юридической науки на украинских землях. В данной статье исследованы проблемы в области железнодорожного транспорта, которые активно рассматривались на заседаниях Киевского юридического общества. Освещены основные шаги в создании единого железнодорожного законодательства в Российской империи во второй половине XIX в., которое было обязательным к исполнению всеми железными дорогами страны. Рассмотрена роль Комиссии по изучению железнодорожного дела в России Е. Т. Баранова, которая была создана с целью изучения вопроса о состоянии железнодорожного дела в стране. Показано, что в состав Комиссии входили ведущие ученые и общественные деятели страны - А. Ф. Кони, С. Ю. Витте, А. А. Вендрих, М. М. Анненков и другие. Указано, что основной целью деятельности Комиссии был сбор необходимых материалов по иностранной и отечественной железнодорожной и судебной практике, которые можно было бы максимально изучить с участием представителей науки, торговли, военного дела и промышленности с целью создания общего устава железных дорог Российской империи, который стал первым кодифицированным источником права именно в железнодорожной деле. Запечатлено, как КЮО принимало участие в данном процессе. Проанализированы выступления отдельных ученых на заседаниях Общества - А. Ф. Кистяковского, Д. И. Пихно, М. Е. Краинского, А. Г. Должанского, А. Ф. Квачевского по проблемам железнодорожной судебной практики, в которых они вносили свои предложения, обсуждали возможности соответствующих изменений в в рамках развития железнодорожной отрасли и вели дискуссии. Кроме того, раскрыта история создания Общего устава железных дорог, его содержание и значение для железнодорожного дела Российской империи, что стало первым шагом в формировании единого правового поля по всей сети российских железных дорог.*

***Ключевые слова:*** *Киевское юридическое общество; железные дороги; юридическая компонента железнодорожного транспорта; Общий устав российских железных дорог*

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