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PREFACE

Oleh Pylypchuk *Editor-in-chief*
Oleh Strelko *Deputy Editor-in-chief*
Yuliia Berdnychenko *Deputy Editor-in-chief*

The issue of the journal opens with an article dedicated to the formation of metrology as government regulated activity in France. The article has discussed the historical process of development of metrological activity in France. It was revealed that the history of metrology is considered as an auxiliary historical and ethnographic discipline from a social and philosophical point of view as the evolution of scientific approaches to the definition of individual units of physical quantities and branches of metrology. However, in the scientific literature, the little attention is paid to the process of a development of a centralized institutional metrology system that is the organizational basis for ensuring the uniformity of measurements.

The article by Irena Grebtsova and Maryna Kovalska is devoted to the of the development of the source criticism's knowledge in the Imperial Novorossiya University which was founded in the second half of the XIX century in Odesa. Grounding on a large complex of general scientific methods, and a historical method and source criticism, the authors identified the stages of the formation of source criticism in the process of teaching historical disciplines at the university, what they based on an analysis of the teaching activities of professors and associate professors of the Faculty of History and Philology. In the article, the development of the foundations of source criticism is considered as a complex process, which in Western European and Russian science was the result of the development of the theory and practice of everyday dialogue between scientists and historical sources. This process had a great influence on the advancement of a historical education in university, which was one of the important factors in the formation of source studies as a scientific discipline.

The article by Tetiana Malovichko is devoted to the study of what changes the course of the probability theory has undergone from the end of the 19th century to our time based on the analysis of The Theory of Probabilities textbook by Vasyl P. Ermakov published in 1878. The paper contains a comparative analysis of The Probability Theory textbook and modern educational literature.

The birth of children after infertility treatment of married couples with the help of assisted reproductive technologies has become a reality after many years of basic research on the physiology of reproductive system, development of oocyte's in vitro fertilization methods and cultivation of embryos at pre-implantation stages. Given the widespread use of assisted reproductive technologies in modern medical practice and the great interest of society to this problem, the aim of the study authors from the Institute for Problems of Cryobiology and Cryomedicine of the National Academy of

Sciences of Ukraine was to trace the main stages and key events of assisted reproductive technologies in the world and in Ukraine, as well as to highlight the activities of outstanding scientists of domestic and world science who were at the origins of the development of this area. As a result of the work, it has been shown that despite certain ethical and social biases, the discovery of individual predecessor scientists became the basis for the efforts of Robert Edwards and Patrick Steptoe to ensure birth of the world's first child, whose conception occurred outside the mother's body. There are also historical facts and unique photos from our own archive, which confirm the fact of the first successful oocyte in vitro fertilization and the birth of a child after the use of assisted reproductive technologies in Ukraine.

In the next article, the authors tried to consider and structure the stages of development and creation of the "Yermak", the world's first Arctic icebreaker, and analyzed the stages of preparation and the results of its first expeditions to explore the Arctic. Systematic analysis of historical sources and biographical material allowed to separate and comprehensively consider the conditions and prehistory for the development and creation of "Yermak" icebreaker. Also, the authors gave an assessment to the role of Vice Admiral Stepan Osypovych Makarov in those events, and analyzed the role of Sergei Yulyevich Witte, Dmitri Ivanovich Mendeleev and Pyotr Petrovich Semenov-Tian-Shansky in the preparation and implementation of the first Arctic expeditions of the "Yermak"icebreaker.

The authors of the following article considered the historical aspects of construction and operation of train ferry routes. The article deals with the analysis and systematization of the data on the historical development of train ferry routes and describes the background for the construction of train ferry routes and their advantages over other combined transport types. It also deals with the basic features of the train ferries operating on the main international train ferry routes. The study is concerned with both sea routes and routes across rivers and lakes. The article shows the role of train ferry routes in the improvement of a national economy, and in the provision of the military defense.

An analysis of numerous artefacts of the first third of the 20th century suggests that the production of many varieties of art-and-industrial ceramics developed in Halychyna, in particular architectural ceramic plastics, a variety of functional ceramics, decorative tiles, ceramic tiles, facing tiles, etc. The artistic features of Halychyna art ceramics, the richness of methods for decorating and shaping it, stylistic features, as well as numerous art societies, scientific and professional associations, groups, plants and factories specializing in the production of ceramics reflect the general development of this industry in the first half of the century and represent the prerequisites the emergence of the school of professional ceramics in Halychyna at the beginning of the 20th century. The purpose of the next paper is to analyze the formation and development of scientific and professional schools of art-and-industrial ceramics of Halychyna in the late 19th – early 20th centuries.

During the environmental crisis, electric transport (e-transport) is becoming a matter for scientific inquiry, a subject of discussion in politics and among public

figures. In the program for developing the municipal services of Ukraine, priorities are given to the development of the infrastructure of ecological transport: trolleybuses, electric buses, electric cars. The increased attention to e-transport on the part of the scientific community, politicians, and the public actualizes the study of its history, development, features of operation, etc. The aim of the next study is to highlight little-known facts of the history of production and operation of MAN trolleybuses in Ukrainian cities, as well as to introduce their technical characteristics into scientific circulation. The types, specific design solutions of the first MAN trolleybus generation and the prerequisites for their appearance in Chernivtsi have been determined. Particular attention has been paid to trolleybuses that were in operation in Germany and other Western European countries from the first half of the 1930s to the early 1950s. The paper traces the stages of operation of the MAN trolleybuses in Chernivtsi, where they worked during 1939–1944 and after the end of the Second World War, they were transferred to Kyiv. After two years of operation in the Ukrainian capital, the trolleybuses entered the routes in Dnipropetrovsk during 1947–1951.

The purpose of the article by authors from the State University of Infrastructure and Technologies of Ukraine is to thoroughly analyze unpaved roads of the late 18th – early 19th century, as well as the project of the first wooden trackway as the forerunner of the Bukovyna railways. To achieve this purpose, the authors first reviewed how railways were constructed in the Austrian Empire during 1830s – 1850s. Then, in contrast with the first railway networks that emerged and developed in the Austrian Empire, the authors made an analysis of the condition and characteristics of unpaved roads in Bukovyna. In addition, the authors considered the first attempt to create a wooden trackway as a prototype and predecessor of the Bukovyna railway.

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The formation of metrology as government regulated activity in France

Abstract. *The article has discussed the historical process of development of metrological activity in France. It was revealed that the history of metrology is considered as an auxiliary historical and ethnographic discipline from a social and philosophical point of view as the evolution of scientific approaches to the definition of individual units of physical quantities and branches of metrology. However, in the scientific literature, the little attention is paid to the process of a development of a centralized institutional metrology system that is the organizational basis for ensuring the uniformity of measurements. It was shown that traditionally there are two periods of development of metrology based on the unification of weights and measures: the association under Charlemagne and the introduction of the decimal metric system during the French Revolution. Because this division has a mixed scientific and organizational basis, a new periodization of the development of French metrology from the position of state regulation was proposed. The highlighted stages include the primitive period and the first city-states, the time of the domination of the Roman Empire, the era of the coexistence of many measures, the chapters of Charlemagne, the feudal practices of the Middle Ages, the creation of royal standards under Henry II, the introduction and dissemination of the decimal metric system, the emergence of metrological institutes, laboratories, centers. At the State level the first step in organizing a centralized institutional metrology system was the creation of a testing laboratory, the second was the creation of National Metrological Bureau, national bodies for metrology, and the third was reorganization of the system and appointment of the National Testing Laboratory as the governing*

metrological body of France. Thus, the French metrology system has experienced many crises and upheavals in the process of its formation. However, France today is one of the most experienced and respected countries in the field of metrology, and at the international level, it was the one who laid the foundations for new metrological agreements, as well as the social, philosophical, scientific, political and geographical area of the new system of measures and weights.

Keywords: *unification of weights and measures; metric system; metrological chaos; system of units of physical quantities; metrological activity*

Introduction.

It is common knowledge that today metrology is a fundamental element of the development of science, industry, and society. Although the importance of metrology in economics of resource reallocation cannot be overemphasized, the term "metrology", that denotes the science of measurements, was introduced only in 1780, and earlier the metrological activity was considered a social practice (Cotteret, 2003, p. 82). This and other aspects are encouraging to study of the historical context of metrology, that allows to trace the occurrence, the spread, the change and disappearance of measures systems, its individual units, and the practice of their use. This, in turn, makes it possible to draw conclusions about the level of socio-economic development of society, international trade intensity, foreign policy relations, and at a less global level – to identify development trends both in the field of metrology and science generally. According to J. Kovalevskiy, head of the French National Metrology Bureau from 1994 to 2005, this task becomes more urgent due to the globalization of the modern world "the metrology is subject to the development of an unprecedented amplitude" (Kovalevsky, 2005, p. 3). There are enough known events in the history of metrology that have global significance for science, and especially it is more interesting to try to understand the difficulties faced by society and what kind of answers were found then to overcome them. From this perspective, the French experience may be cognitive, since France was the first to reform the measures system toward its unification and was among the first countries of the initiators of the signing of the Metric Convention.

J.-C. Hocquet and his fundamental work "Historical metrology" (Hocquet, 1995; Hocquet, Garnier & Woronoff, 1989) and other works made a significant contribution to the study of the history of French metrology about the origin and spread of the metric system, the variety of measures and weights of ancient France, measurements and weighing over the centuries, etc. Moreover, French scientists explore the history of measures of length and area (Reguin, 2021), water measurements (Mathieu, 2001), teaching metrology (Cotteret, 2003), metrology practices before the French Revolution (Guyotjeannin, 1987), the relationship between metrology and standardization (Bryden, 2012), the overall history of measurements (Jedrzejewski, 2020), the impact of individual organizations on French metrology (Petitgirard, 2015). Studying of the works shows their overall perception of metrology as a universal human collective activity,

which, however, is not practiced uniformly. Moreover, these differences can be simultaneously both the consequence and the reason for the need for change existing principles, trends and mechanisms in science, legal systems, practices that reside within metrology. However, the scientific literature paid very little attention to the process of creating a centralized institutional metrology system that is the organizational basis for ensuring the uniformity of measurements.

In this regard, the purpose of article is to study the process of the formation of metrology as an activity, regulated by government in France as one of the countries with global influence in this area.

Theoretical foundations.

Based on the sources mentioned above it can be argued that in the scientific literature, there are several approaches to the study of the history of metrology: it is treated as an auxiliary historical and ethnographic discipline; it is treated from a social and philosophical point of view; it is treated as an evolution of scientific approaches to the definition of individual units of physical quantities and branches of metrology. In the aspect of the state organization of metrological activities in France decided to allocate two periods: the association under Charlemagne and the introduction of the decimal metric system during the French Revolution. These aspects are based on the unification of weights and measures. In our opinion, such a division is not correct enough, since it has a mixed scientific and organizational basis, mainly associated with the definition of units of physical quantities. And, although the achievements of scientific metrology are of key importance for the development of this activity, we propose to divide the history of French metrology from the position of state regulation into ten stages, a description of which is presented in the section «Results and discussion»: 1) the incipience of weights and measures; 2) the first form of legal metrology; 3) “metrological chaos”; 4) chapters of Charlemagne; 5) feudal practices; 6) the creation of royal standards; 7) the introduction of the decimal metric system; 8) the plurality of metrological organizations; 9) national metrological organizations; 10) creation of a unified state sustainable structure.

Results and discussion.

At the first stage of the existence of human civilization, in the Paleolithic era, hunters and gatherers, apparently, did not have metrological practice. However, the work (Jedrzejewski, 2020) said, that at that time there were objects that looked like graduated rulers, namely fragments of bones or stones with evenly spaced parallel incisions, while there is no one confirmations of their use as measuring instruments. Climate softening, the transition to a sedentary lifestyle, the rapid evolution of human societies led to the Neolithic revolution, namely, to the transition from gathering and hunting to agriculture and animal husbandry, on the territory of modern France this happened about 10,000 BC. In addition, the emergence of the need to exchange

surplus agricultural products inevitably led to the invention of the first stone measures of weight.

The gradual development of society led to the emergence of city-states and large trading colonies such as Massilia (by around 600 BC, modern Marseille), in which the processes of economic exchange were significantly different from average Neolithic villagers. New forms of economics have transformed social activities related to the production, management, establishment, and leadership. Redistribution of production, tax increases, exchange of surplus in the markets, trade with neighboring cities led to the need for accounting and metrology. The fact that the oldest weights are unmarked indicates to a time where "metrological activity was not subordinate to authorities, but existed on trusting relationships between people and groups" (Cotteret, 2003, p. 104).

In antiquity on the territory of modern France (2nd century BC – 5th century CE) all types of taxes and fees in monetary or raw material form were calculated by Roman measures. Their standards were often made of stone and kept in the Temple of Jupiter in Rome, but also in the most visited shopping places. There was a position of an inspector for checking weights and measures, who had the right to destroy false measures (Hocquet, 1995). This fact as well as control of the production of coins under the leadership of the proconsul of Gaul in Lyon could call it the first form of legal metrology in France.

After the fall of the Western Roman Empire, the tribes of the Burgundians, Visigoths, and Franks came to Gaul, which, in turn, brought their measuring systems. The coexistence in the same time and space of these, as well as Roman, Arabic, Greek, Gali measures and weights has led to what many researchers call "metrological chaos". The first attempt to regulate it at a national level was performed by Charlemagne in 779. He combined measures, weights, and coins and they still acquired a fixed value throughout the empire even if they retained the Roman name. In addition, he increased the numerical values of the measures, which changed the entire system, and reorganized the monetary system, basing it on a new standard of weight, namely, the grain of wheat. Such acts showing that Charlemagne "had an understanding of the essence of the measure and its structuring role" (Cotteret, 2003, p. 119). During his reign, (768-814) standards were stored in churches and his palace, and inspectors, whose activities were intended to guarantee fair trade, regularly checked all measures. It took Charlemagne almost 20 years to introduce a unified metrological system that operated only under his rule. He was thinking big for his time, and his empire was too large and did not have a sufficiently developed transport infrastructure to support uniform measures throughout its territory (Hocquet, Garnier & Woronoff, 1989).

During the Middle Ages, the unified system of measures and weights of Charlemagne underwent more and more changes, namely, feudal Lords declared their sovereign rights to measurements, established measures, determined their numerical value depending on the circumstances. The standards were in the custody of feudal

judges, the vassals focused their measures on the measures of the Lord. There was a paid official position, which requires swearing to the Lord and consisted in tracking fraud and punishing violations (Hocquet, 1995). Without official regulation, collections and rule books appeared that systematized local metrological practices and gradually replaced Charlemagne's obsolete chapters.

In 1321, Philip V attempted to unify measures, weights, and coins. He ordered the assembly of the Estates General to resolve this issue and work on reform, but he met the categorical refusal of the Lords and clergy, motivated by the fact that this unification supported only royal interests. Being the forming of state representative institutions, which had convened at the initiative of the royal government to assist the government. The Estates General nevertheless sought to find ways to contain it and advance the interests of the estates. At their insistence in 1558, Henry II proclaimed a decree on the unification of measures in all territories falling under the jurisdiction of the court of the Paris parliament, and "all feudal measures had to correspond to the royal standard, placed in the Paris city hall under the supervision of the mayor or his deputy" (Cotteret, 2003, p. 128).

Considering the flourishing royal absolutism, Estates General meetings had no longer held until 1789 despite the accumulated contradictions in society that demanded cardinal reforms, including and in the field of metrology activities. Previous attempts by the Minister of Finance A. Turgot to establish the unity of measures because of a unit of length throughout the entire territory of the state did not find support from the last French king Louis XVI. Also, the next Minister of Finance J. Necker expressed doubts about the success of this idea, given the changes that would need to be made in all areas of activity (Cotteret, 2003, p. 131). Therefore, among other requirements also were the numerous books of complaints of the provincial assemblies, sent with deputies to the Estates General, contained various metrological problems of that time. These books gave rise to many abuses and fraud at the local level, and massively demanded the unification of weights and measures, as well as their calibration and labeling.

By the beginning of the Great French bourgeois revolution, the commission of the Academy of Sciences on the project of uniformity of weights and measures concluded that the scientific basis for this was sufficiently developed. In 1790, the report "Observations of the Royal Agricultural Society on the Uniformity of Weights and Measures" was submitted to the National Assembly. This report summarized the current scientific research in the field of metrology at that time. The result was a decree of the National Assembly on the rationing of measures and weights, prescribing to draw up a scientific substantiation of a new system of measures and a table of the ratio of new and old measures, to take an inventory of local measures, and to make temporary standards. Moreover, in 1795, the unification of measures and weights law was adopted, which introduced the decimal metric system in France, standards uniform for the whole country, the procedure of their manufacture, storage, verification, and the position of an auditor of standards in each district (Hocquet,

Garnier & Woronoff, 1989). Although in 1812 and 1816 Napoleon Bonaparte issued decrees, leading to change the original purity of the decimal metric system, this law remained basic and was revived in 1837 when the metric system became mandatory for all commercial transactions in France.

The year before the law in 1795, the National Conservatory of Arts and Crafts (Cnam) was created, designed to produce and distribute metric standards, both within France and in other countries. In 1848, national standards were deposited at Cnam from the Provisional Bureau of Weights and Measures of the Department of Commerce. This organization became one of the leading in the metrology field in France. In addition, this organization became the center of all promotional activities for the decimal metric system in the XIX century and slowly but surely spread in Europe. Back in 1797, French Foreign Minister Charles de Talleyrand organized the first international meeting on metrology to verify the calculations of the numerical value of the meter. However, the World Exhibitions of 1851, 1855, and 1867 show significant differences in measures in different countries. In this regard, the International Metrology Commission was created in 1869, the French section of which took on the task of implementing a new standard for the meter. The result of the commission's activities was the signing in Paris in 1875 of the International Metric Convention and the creation of the International Bureau of Weights and Measures (BIPM).

The next step in the development of the French metrological system was the creation of the "National Scientific and Permanent Bureau of Weights and Measures" in 1880 based on Cnam, which had previously met the needs of "conventional metrology" rather than scientific (Petitgirard, 2015, p. 22). Rapid industrialization at the end of the 19th century and a growing need for measuring instruments and their verification in the industry led to the creation in 1901 testing laboratory (LE) on the initiative of the Society of Civil Engineers. The laboratory was based on Cnam and administered by the Ministry of Foreign Trade and the Chamber of Commerce and Industry. In addition, since 1900, several reputable organizations have been operating in the field of metrology in France at the same time, namely, Central electrical laboratory (LCE, from 1882), Observatory of Paris of time measurement, Commissariat for Atomic and Alternative Energy (CEA, from 1945). The absence of a centralized integrated system, the unclear definition of the mission and objectives of LE, lead to the crisis of the 1930s. Apart from electricity and lighting, France was not represented on the International Committees for Weights and Measures; metrology is divided between LE, LCE, BIPM, and private laboratories, LE fails to maintain a balance between measuring instruments control and scientific activities.

This generally continued until the late 1960s, when rapid economic growth at "The Thirty Glorious" exacerbated existing metrology challenges. He showed the need for a testing and control laboratory to serve the industry and for basic, scientific, referral testing and research (Petitgirard, 2015). This led to the creation in 1969 of the National Institute of Metrology (INM) for scientific research, the National Testing Laboratory (LNE) for the verification and calibration of industrial measuring instruments, the

National Bureau of Metrology (BNM) to coordinate the activities of metrology organizations. This step ended several decades of debates, pioneered the 35-year restructuring of French metrology, and created an inter-agency coordination mechanism for the major players in metrology, facilitating the development of metrology activities, funding and interaction with industry. Until that time, in France, unlike in other countries, there were no single agency to manage metrological activities at the national level.

A natural consequence of this, and also following international trends, in 1982 the National Testing Network (RNE) was organized, whose purpose was to identify and mark the conformity of testing laboratories, and in 1993 the BNM Committee for Accreditation of Calibration Laboratories (FRETAC) was established. In 1994, the accreditation of laboratories and certification bodies transferred to the specially created French Accreditation Committee (COFRAC), and the BNM received the status of a public group (GIP). Created over several years with updates, that were not obvious, the situation at BNM proved to be completely incompatible with its continuing responsibilities in industry, commerce, healthcare, and the environment. For this reason, in 2005, BNM was finally taken over by LNE, a stable structure that in this case became the National Laboratory for Metrology and Testing. Today the LNE manages metrology in France in cooperation with Cnam, CEA, and the Paris Observatory under the leadership of the Ministry of Economics.

Conclusions.

Today the metrology is the universal language of science and technology, but its development throughout history has varied from a form of support for private interests to the exchange of a universal public metrological good. The latter became possible thanks to the state regulation of metrological activity, which organizationally ensures and maintains the uniformity of measurements. Several historical attempts to put it into practice have been identified. However, the first effective step in organizing a centralized institutional metrology system was the creation of the LE, the second was the creation of the BNM, the national metrology body, and the third step was the reorganization of the system and the LNE assignment as the governing metrology body in France. In addition, although we contested the traditional division of the development of metrology in France based on the unification of weights and measures, nevertheless, it should be noted that there is a fundamental difference in the organization of ancient and new measures and weights. It lies not only in the metrological principles that served as the basis for the decimal metric system but also in the equalization of citizens' rights in access to the public good.

Generally, the French metrological system in the process of its formation has experienced many crises and upheavals. However, today France is one of the most experienced and reputable countries in the field of metrology and at the international level, it was the one who laid the foundations for a new metrological agreement and social, philosophical, scientific, political, and geographical area of the new system of measures and weights.

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Становлення метрології як державно регульованої діяльності у Франції

Анотація. *У статті розглянуто історичний процес розвитку метрологічної діяльності у Франції. Виявлено, що історію метрології розглядають як допоміжну історичну та етнографічну дисципліну, з*

соціальної та філософської точок зору, як еволюцію наукових підходів до визначення окремих одиниць фізичних величин і галузей метрології. Однак, в науковій літературі приділено мало уваги процесу створення централізованої інституційної метрологічної системи, яка є організаційною основою забезпечення єдності вимірювань. Встановлено, що традиційно виділяють два періоди розвитку метрології, заснованих на уніфікації мір і ваг: об'єднання за Карла Великого і поява десяткової метричної системи під час Французької революції. Оскільки такий розподіл має змішану науково-організаційну основу, запропоновано нову періодизацію розвитку французької метрології з позиції державного регулювання. Виділені етапи включають первісний період і перші міста-держави, час панування Римської імперії, епоху співіснування безлічі мір, капітули Карла Великого, феодальні практики Середньовіччя, створення королівських еталонів за Генріха II, введення і поширення метричної десяткової системи, виникнення метрологічних інститутів, лабораторій, центрів. На державному рівні першою спробою організувати централізовану інституційну метрологічну систему було створення випробувальної лабораторії, другим – Національного метрологічного бюро, національного органу з метрології, а третім – реорганізація системи і призначення Національної випробувальної лабораторії керівним метрологічним органом Франції. Французька метрологічна система в процесі свого становлення зазнала безліч криз і потрясінь. Проте, Франція сьогодні є однією з найдосвідченіших і авторитетних країн в сфері метрології, а на міжнародному рівні саме вона заклала основи нового метрологічного договору, а також соціальний, філософський, науковий, політичний і географічний ареал нової системи мір і ваг.

Ключові слова: *уніфікація мір і ваг; метрична система; метрологічний хаос; система одиниць фізичних величин; метрологічна діяльність*

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Становление метрологии как государственно регулируемой деятельности во Франции

Аннотация. *В статье рассмотрен исторический процесс развития метрологической деятельности во Франции. Выявлено, что историю метрологии рассматривают как вспомогательную историческую и этнографическую дисциплину, с социальной и философской точек зрения, как эволюцию научных подходов к определению отдельных единиц физических*

величин и отраслей метрологии. Однако, в научной литературе уделено мало внимания процессу создания централизованной институциональной метрологической системы, которая является организационной основой обеспечения единства измерений. Установлено, что традиционно выделяют два периода развития метрологии, основанных на унификации мер и весов: объединение при Карле Великом и появление десятичной метрической системы во время Французской революции. Поскольку такое деление имеет смешанную научно-организационную основу, предложено новую периодизацию развития французской метрологии с позиции государственного регулирования. Выделенные этапы включают первобытный период и первые города-государства, время господства Римской империи, эпоху сосуществования множества мер, капитулы Карла Великого, феодальные практики Средневековья, создание королевских эталонов при Генрихе II, введение и распространение метрической десятичной системы, возникновение метрологических институтов, лабораторий, центров. На государственном уровне первым этапом организовать централизованную институциональную метрологическую систему было создание испытательной лаборатории, вторым – Национального метрологического бюро, национального органа по метрологии, а третьим – реорганизация системы и назначение Национальной испытательной лаборатории руководящим метрологическим органом Франции. Французская метрологическая система в процессе своего становления испытала множество кризисов и потрясений. Тем не менее, Франция сегодня является одной из самых опытных и авторитетных стран в сфере метрологии, а на международном уровне именно она заложила основы нового метрологического договора, а также социальный, философский, научный, политический и географический ареал новой системы мер и весов.

Ключевые слова: *унификация мер и весов; метрическая система; метрологический хаос;, система единиц физических величин; метрологическая деятельность*

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The development of the foundations of source criticism as a scientific discipline at the Imperial Novorossiya University

Abstract. *The article is devoted to the study of the development of the source criticism's knowledge in the Imperial Novorossiya University which was founded in the second half of the XIX century in Odesa. Grounding on a large complex of general scientific methods, and a historical method and source criticism, the authors identified the stages of the formation of source criticism in the process of teaching historical disciplines at the university, what they based on an analysis of the teaching activities of professors and associate professors of the Faculty of History and Philology. In the article, the development of the foundations of source criticism is considered as a complex process, which in Western European and Russian science was the result of the development of the theory and practice of everyday dialogue between scientists and historical sources. This process had a great influence on the advancement of a historical education in university, which was one of the important factors in the formation of source studies as a scientific discipline. The history of individual scientific disciplines cannot be understood outside the context of the development of science altogether, therefore the authors paid attention to the change of scientific paradigms in the period under the study. It is noted that reforms in the field of education and the development of European historical knowledge have become the main components of the formation of historians, who, with their scientific activities at the theoretical and practical levels, contributed to the development of the special historical disciplines. The article reveals a gradual increase in the number of courses taught at the historical department of the Faculty of History and Philology, in which teachers used the opportunity to teach students to work with various types and kinds of sources. The authors examine the contribution of the historians of Odesa*

in the XIX – early XX century in the process of institutionalization of historical disciplines, in the formation of a complex of special historical disciplines, which resulted in the actualization of their scientific works in subsequent years. As a result of the study, the authors came to the conclusion that the professors of the departments of general and Russian history, with their teaching and scientific activities, laid the foundations of source criticism as a special scientific discipline, raising theoretical problems in their lecture courses, and at the training workshops, teaching students how to work with sources in practical terms.

***Keywords**: historical sources; professors; students; special historical disciplines*

Introduction.

The formation of scientific knowledge is characterized by a large number of abrupt changes, a turnarounds that determine a methodological search. Usually, the result of these processes is the emergence of new directions and disciplines. Science has always developed within the framework of the opening horizons of opportunities and prospects that were dictated by the level of socio-cultural development of society. The search for methodological foundations in historical science is also a characteristic for the 19th century, when the theoretical and methodological apparatus was developed, the process of accumulating the source base of historical research was going on, the methods of analyzing sources were tested and approved. In the first half of the 19th century, which is commonly called The era of Romanticism, a historical science was influenced by literary style traditions. The method of humanitarian thinking was characterized by a direct appeal to the source, the desire to perceive the work as a whole, perceiving and figuring out the personality of the author through it. The enthusiasm for folklore, everyday life, and traditions, was an eminent characteristic of this period, and had been reflected in the collection and publication of sources covering them.

In the second half of the XIX century, the methodology of natural and social sciences was increasingly influenced by the Positivism, whose paradigm is characterized by the rejection of speculative schemes and arbitrary interpretations of facts, the desire to prove the results of a scientific research. The attitude towards the source has changed. Followers of Positivism emphasized the importance of different types and kinds of written sources; they managed to raise a source criticism to a new professional level, contributed to the scientific development of its theory and practice. These processes embraced Western European science, spread to the territory of the Russian Empire, and found their manifestation in Ukrainian universities, including the Imperial Novorossiya University founded in Odesa in 1865.

The university science is rightfully proud of the plethora of eminent scholars who, over the centuries, laid the foundation of modern scientific knowledge exactly because of their sparkly activities. The history of European universities and the scientific activities of their teachers are widely covered in the works of modern foreign and domestic researchers. The English researcher R. Anderson in the

monograph "The European Universities From the Enlightenment to 1914" highlighted the stages of development of university education, characterized the emergence of three university models, their transformation and related institutional and functional changes in European higher education, focused on the history of the formation of leading European universities (Anderson, 2004). Such researcher as T. Howard revealed the influence of Protestantism on the development of German universities and the disciplines taught in them (Howard, 2006). The interest of foreign scientists in university education in the Russian Empire and the contribution of professors to the social and educational system is traced (Maurer, 1998). The problem of the relationship between the Russian tsarism and the universities is reviewed by R. Friedman (2006) in his work "Masculinity, Autocracy and the Russian University. 1804–1863". The fundamental collective monograph edited by the historian T. Sanders "Historiography of Imperial Russia: The Profession and Writing of History in a Multinational State" (Sanders, 1999) is devoted to the historical science of the Russian Empire.

Various aspects of the development of the university education are widely covered in the Russian historiography. Such researcher as A. Y. Andreev examined in his works the development of universities in the Russian Empire in the context of the university history of Europe (Andreev, 2009). In recent years, a number of works have appeared that analyze the teaching staff of Russian universities and their contribution to the development of science (Faculty..., 2011), professional ethics of university professors (Vishlenkova, Galiullina & Ilyina, 2012) and other aspects of the problem. A methodological aspects of source criticism in historical retrospective, the influence of the historical context and paradigms of scientific trends on their formulations and solutions are considered in the work of the Russian researcher Yu. A. Rusina (Rusina, 2015).

Nowadays, attention to this problem raised in the Ukrainian historical science again. The researcher O. B. Yas devoted his innovative article to the peculiarities of methodological searches, the "great turnpoints" in historical science, and the transformation of scientific knowledge (Yas, 2018). Among the numerous transformations, a prominent place belongs to the "disciplinary turn", the features of which are discussed in the monograph of T. M. Popova. The researcher raised the problem of the relationship between the "turnpoints" and a new disciplinary formations. The author regards a wide range of issues related to the understanding of a "disciplinarity" as an intellectual and sociocultural phenomenon (Popova, 2019).

The stages of development of Ukrainian source criticism were covered in the research of E. M. Bogdashina. The author assigns a noticeable place in this process to the role of historians of the XIX century (Bogdashina, 2005). Some aspects of the study and use of the methods of criticism of historical sources in Odesa educational institutions were considered by I. S. Grebtsova in the theses of the scientific conference (Grebtsova, 2020).

At the same time, the contribution of Odesa university historians to the formation of source criticism knowledge has not yet found its coverage in the research literature.

The *purpose* of the study is to analyze the stages of the development of theoretical knowledge about historical sources and practical skills of working with their various types and kinds among students-historians of the Faculty of History and Philology of the Imperial Novorossiya University.

The *chronological* boundaries of the study cover the period from 1865 to 1920 – the time of the existence of the Imperial Novorossiya University, when, at the Faculty of History and Philology, there was a process of formation of knowledge about sources, courses were taught that guided students to work with them, also.

The *tasks* of this study are:

– to identify the techniques and methods of teaching students the basics of source criticism at the Faculty of History and Philology of the Imperial Novorossiya University;

– to characterize the stages of the development of source knowledge at the university.

The *source base* of this research was the materials published and kept in the State Archive of the Odesa region about the teaching activities of the historians: an office documentation of the Imperial Novorossiya University, first of all, the curricula of the courses of the Faculty of History and Philology and reports on the activities of the faculty and the university; ego-materials (the students' memories about their university professors), as well as dissertations, articles and monographs of historians who taught at the Imperial Novorossiya University, in which their knowledge and skills in the field of source criticism are reflected to one degree or another.

The "Teaching Reviews at the Imperial University of Novorossiya" that published annually allows us to trace the formation and development of courses in the source studies, that later were taught at the Faculty of History and Philology. This edition periodically clarified and updated the title, but its content remained the same: a list of courses read by teachers and the literature recommended for them. The problem of a student–teacher is revealed in an article on the basis of his published materials – a student memories, included in the publication "The Novorossiya University in the memories of contemporaries" (1999). The complex of historiographical sources is represented by the scientific works of historians who taught at The Novorossiya University: dissertations, articles and monographs, in which their knowledge and skills in the field of source studies mainly manifested. Significantly the source base of documents expanded on teaching and scientific activities of historians, stored in the State Archives of Odessa region (DAOO): the fund 44 (The Richelieu Lyceum), the fund 45 (The Novorossiya University), and personal funds of professors – fund 153 (I. A. Linnichenko). Thus, the source base of

the study, which is very wide in terms of types, makes it possible to reveal its goals and objectives.

Research methods.

The article applied a set of methods: general scientific (analysis, synthesis), the special historical methods (a historical genetic method, and historical comparative method) and source studies (heuristic method, source analysis). The historical genetic method involves the study of sources and facts in its transformation. Its essence lies in the consistent disclosure of the properties and changes of the investigated sources and facts. The historical genetic method makes it possible to identify cause-and-effect relationships in the formation of source criticism as a special historical discipline, to characterize sources and events in their individuality and imagery. The historical comparative method allowed to compare the level of development of source criticism knowledge at different departments in different periods. The heuristic method made it possible to identify the most significant sources and facts on the problem under study, and the source analysis – to interpret them. The problem-chronological method was also used, which provided a representation of the problems under consideration in chronological order. The biographical method was used to study the basics of life, scientific and teaching activities of the scientists that had been working at the Imperial Novorossiya University.

Results and discussion.

In the course of studying this problem, first of all, a number of factors should be distinguished, the main positions of which are:

– the approval of Rankeanism in European and American historiography with its critical attitude to the source;

– the Positivists' entry into the historical arena, because their merits lie in the comprehensive development of internal and external criticism of sources;

– the reforms undertaken by Alexander II in the Russian Empire in the 1860s – 1870s, including the area of science and education.

The Novorossiya University in Odesa was the fourth higher education institution in Ukraine after the universities found in Lviv, Kharkiv and Kyiv. Its activity coincided chronologically with the time of completion of the process of institutionalization of historical science, the formation of new branches of historical knowledge, the formation of the new historical disciplines also. In the course of this process, a scientific and educational work of teachers of the departments of general and Russian history, carried on the philological faculty of the Novorossiya University. Many of them managed to contribute to the disciplinary formation of the two important disciplines: a historiography and a source studies.

Teachers of the Department of World History took an active part in the formation of courses in source studies and the establishment of a source studies as a new discipline. The Professor O. G. Brikner (1834–1896) stood at the origins of this

process. In his youth, he graduated from the Peter and Paul School in St. Petersburg, then attended lectures of the famous professors at the Heidelberg, Jena and Berlin universities. In 1864, in St. Petersburg, the young scientist defended his dissertation for a magister's degree in history, and three years later he defended his doctoral dissertation at the University of Dorpat (nowadays Tartu). In the spring of 1867, the defense of his doctoral dissertation allowed O. G. Brikner to become a professor at the Department of World History of The Novorossiya University. In addition to courses on the history of the Ancient world and the Modern times, the scientist read several theoretical and methodological courses at The Novorossiya University. The title of one of them was "The Encyclopedia and Methodology of History" and it was borrowed by him from J. G. Droysen, whom he considered the best sciencifical star of those in Berlin. O. G. Brikner's course "The Historical Criticism" became a purely source study course, in the course of which the scientist covered one of the most important source study problems, teaching students how to work with sources. As his students said, all of the O. G. Brikner's lectures and workshops were characterized by "a liveliness of presentation" and an emphasis on sources. The University graduate O. Kolyankovsky stated: "The audience always listened eagerly to the words of their beloved professor, and I remember how annoying it happened at the moment when the bell rang down the corridor meaning that the interesting lecture had already ended" (The Novorossiya University in memoirs, p. 54). However, O. G. Brikner would not have been working at The Novorossiya University for a long time, for in 1872 he became a professor at the Dorpat University and later at the Kazan University.

A prominent representative of this department was a graduate of the St. Petersburg University, Professor F. I. Uspensky (1845–1928), a student of K. N. Bestuzhev-Ryumin. He began teaching at the Novorossiya University in 1874 as an assistant professor. F. I. Uspensky in 1879 successfully defended his doctoral dissertation "The Formation of the Second Bulgarian Kingdom" and became a professor at the University. Reading the history of the ancient world and the Middle Ages, the scientist conducted a training workshop "Practical exercises: reading sources on ancient and medieval history" (The Review of Teaching, 1890, p.12). His scientific interests gravitated towards the history of Byzantium. F. I. Uspensky collected, systematized and published an array of valuable sources, which even nowadays are a significant part of the main collection of sources on the history, art and culture of Byzantium and the South Slavic nations. During his work at the University for a twenty years, the historian studied not only sourses as a written text, but also material sources, and had developed the methods for their analysis. On F. I. Uspensky's initiative, in 1895, the Russian Archaeological Institute was established in Constantinople, which he headed until 1914.

O. S. Trachevsky (1838–1906), who taught at the Department of the World History, was a graduate of the Moscow University and a student of S. M. Soloviev and S. V. Eshevsky. He defended his doctoral dissertation in 1877 and was elected an

ordinary professor of the Novorossiya University, where he had been working successfully until 1890 (DAOO. F. 45. Inv. 4. F. 2545. P. 16). The scientist lectured on modern and contemporary history, a special course on the history of the Reformation in Western Europe and conducted a training workshop "The history of Humanism as one of the elements of the Reformation", which was a practical exercise for the students who were read and commented the works of Erasmus of Rotterdam (Review of Teaching, 1895, p. 6). Teaching his students how to analyze literary and journalistic sources, O. S. Trachevsky contributed to the development of the foundations of practical hermeneutics.

At that Department in the middle of 1890ies, the extraordinary professor R. Yu. Vipper (1859–1954) worked. The scientist was born and studied in Moscow, where he spent most of his life. During his student` years at the Moscow University, the Professor of the World History V. I. Gerje had a special influence on his scientific outlook. In 1892, while on a scientific trip to Geneva, R. Yu. Vipper studied sources on the history of Calvinism. The result of the journey was the successful defense of the dissertation "The Church and State in Geneva in the 16th century" in 1894, for which the scientist received not only a magister's degree, but also a doctor's degree. After defending his thesis, he was invited to the Imperial Novorossiya University. In his theoretical course "The Global Problems of Historical Science", the historian paid attention to the problems of working with sources (Review of Teaching, 1895, p. 15).

In the late 1890ies E. M. Schepkin (1869–1920) was elected an Extraordinary professor of this department. A graduate of the Moscow University, a student of V. I. Ger'e and P. G. Vinogradov, he worked at the Moscow University in 1891 The Novorossiya University 1894 as a privat-docent of the Department of World History. In 1893 the scientist went abroad in order to get acquainted with the teaching of history in foreign universities and collect sources in the archives of Denmark, Germany and Austria for further scientific work. At this time, E. M. Schepkin got acquainted with the works of Leopold von Ranke and adopted a number of his source criticism techniques. In 1897 he worked at the Nezhensky Institute of History and Philology of Prince Bezborodko, but the very next year he began teaching at the Imperial Novorossiya University in Odesa. In addition to the lectures on the history of Western Europe, he prepared an author's course on the "Historical methodology; theoretical and practical course", which also included his achievements in the field of source criticism (Review of Teaching, 1900, p. 12–13). As a textbook for this course, E. M. Schepkin offered to the students the works of famous positivist scientists such as E. Bernheim, C. Langlois and S. Senobos (Review of Teaching, 1900, p. 13). At the beginning of the twentieth century, E. M. Shchepkin immersed himself into politics, but did not retire from the research activities. His scientific and journalistic heritage is about 300 works, among which the main place is occupied by the problem of international relations in Europe. E. M. Schepkin devoted a number of scientific works to the methodology of history and source criticism.

In the process of a formation of the source study knowledge among students, an equally noticeable role belongs to the teachers of the Department of Russian History. For 12 years in the initial period of the university's existence, this department was headed by M. P. Smirnov (1833–1877) who was a graduate of the Main Pedagogical Institute in St. Petersburg, but before that he had previously taught at the Richelieu Lyceum in Odesa. The views of the historians N. G. Ustryalov and S. M. Soloviev had a great influence on the development of the M. P. Smirnov's historical concept. The M. P. Smirnov's doctoral dissertation "Yagailo – Yakov – Vladislav and the first Polish–Lithuanian Union" was devoted to the problems of Ukrainian–Polish–Lithuanian history. In his scientific works, the scientist studied a wide representative source base. He taught students the history of Russia from the ancient age to the 16th century, pursued the special course "the History of Peter The Great's reign". However, the scientific interests of that scholar were much broader. He was a specialist in the history of Central and Eastern Europe in the late Middle Ages, therefore, after O. G. Brikner has left, in the first half of the 1870ies he taught a course in the modern history of Prussia at the Department of The World History.

An important feature of M. P. Smirnov's activity as teacher was the desire to acquaint students more deeply with historical sources, on the basis of which he prepared his lectures. The scholar called the sources "the old monuments of the social life of our ancestors" (DAOO. F. 44. Inv. 3. F. 27. P. 20). In his views upon sources and their significance for a historian, he generally adhered to a positivist trend, although he had not yet completely departed from the previous romantic stage of the development of historical science. However, M. P. Smirnov did not prepared courses on source studies. In 1871, M. P. Smirnov was elected as Dean of the Faculty of History and Philology; in 18741–877 he was acting Vice-Rector of the University.

And then, S. M. Soloviev's student G. I. Peretyatkovich (1840–1908) was the successor of M. P. Smirnov at the Department of Russian History. A native of Bessarabia, he studied at the office department of the Richelieu Lyceum in Odesa, and got his higher education at the Faculty of Law of the Moscow University and its pedagogical courses where he studied history. After doing a degree of his magister's thesis at Moscow University, the scientist began to work as the Associate Professor at the Department of Russian History at the Imperial Novorossiya University, G. I. Peretyatkovich was sent to the Moscow University in the early 1880s with the purpose to work on his doctoral dissertation. During this period, he worked hard drafting his dissertation, adding new sources and materials, which he began to write while teaching in Odesa. A successful defense of his doctoral dissertation "The Volga region in the 17th century and at the beginning of the 18th century" took place in 1882 at the Moscow University. A huge advantage of the scientist's works was the using of an array of archival documents as a source base. After defending his doctoral dissertation, he was elected as Professor of the Department of Russian history at the Imperial Novorossiya University. With his arrival at the department, an interest in the problem of the institutionalization of historical knowledge was highly raised. In

addition to the general course on the history of Russia, G. I. Peretyatkovich taught for a long time the courses "The Review of the most important sources and manuals for acquaintance with Russian history", "The Russian historiography". He also led a work on the seminars "Reading and Explaining Sources on Ancient Russian History", which was nothing more than the preparation of future historians to work with historical sources (The Review of Teaching, 1892, p. 17). In comparison to M. P. Smirnov who theorised in his lectures the need for students to work with sources, we may say that G. I. Peretyatkovich already taught them to do it in practice. The scholar belonged to the big names of positivist historians and was very attentive to the problem of facts and their intergration in sources. According to his own theoretical positions, he used to tend to a detailed analysis of sources, avoiding broad generalizations.

Among the teachers of Russian history of the Faculty of History and Philology, a prominent place belongs to O. I. Markevich (1847–1903). A native of the Cossack-elders' clan, a native of the Poltava province, a graduate of the Faculty of History and Philology of The Imperial Novorossiya University, he formed as a scientist under the influence of Odesa professors F. I. Leontovich and F. K. Brun. For some time he worked in Taganrog. O. I. Markevich was transferred to Odesa in 1871 as a teacher of Russian literature at the Odesa Commercial School. In 1879, at the Kyiv University, he defended his magister's dissertation, and then in the fall of 1880, he became an Assistant Professor of the Department of Russian History at the Imperial Novorossiya University. O. I. Markevich, who had wide scientific interests, identified and systematized historical sources for all the courses he taught. He studied carefully the development of chronicles, he collected and studied sources on the history of the university, and developed a coup of courses in the special historical disciplines: a historical geography, a historiography, an ethnography.

O. I. Markevich in 1888 defended his doctoral dissertation "The History of Parochialism in the Moscow state" at the Kyiv University, soon becoming an Extraordinary Professor, and then an Ordinary Professor of the department of Russian history. Using a wide range of sources, the author interprets parochialism as a relic of the period of feudal fragmentation, which hindered the development of the state. As a professor, O. I. Markevich led a general course on the history of Russia and prepared about 20 special courses. He taught students how to work with sources providing a special course "The History of the First Impostor", part of which was a practical lesson called "Reading and Explaining Sources on the History of an Impostor". He continued the matter also while teaching the course "The Polish period of the history of South and Western Russia: acquaintance with sources and manuals for the history of the period" (Review of Teaching, 1895, pp. 16–17). He had wrote more than 400 works, many of which are fundamental researches. The students liked O. I. Markevich's bright lectures very much. O. Levitsky, a graduate of the Faculty of History and Philology, wrote about O. I. Markevich: "Odesa knew him well, his activities completely belonged to her; and there are few people who enjoyed such

great popularity among the most diverse strata of the population of Odesa ...” (The Novorossiya University in memoirs, p. 51).

In October 1884 I. A. Linnichenko (1857–1926), a graduate of the Kiev Imperial University of Saint Vladimir, a student of V. B. Antonovich, became an Assistant Professor of the Department of Russian History of the University. In the mid 1880s, at the Faculty of History and Philology, he taught a course on the history of Kyivan Rus` and a course of the Russian historiography. At the beginning of 1886 he got to do a scientific journey to collect materials for writing his doctoral dissertation. While working on his thesis, I. A. Linnichenko taught at the Moscow University. Then he became one of the founders of the “Slavic Commission” as a part of the Moscow Archaeological Society. In May 1894, at the Kyiv University, he successfully defended his doctoral dissertation “Features from the history of the estates of Southwestern (Galician) Rus in the 14th – 15th centuries; The Research”. The work was written in line with the tradition of famous Ukrainian scientists such as V. B. Antonovich, F. I. Leontovich, M. F. Vladimirsky-Budanov.

In March 1896, I. A. Linnichenko returned to Odesa in a new status. The scientist was elected a Professor of the department of Russian history at the Imperial Novorossiya University, where he taught a general course and conducted a training workshop called “Practical exercises in Russian history: reading, translating and interpreting the most important historical monuments” (The Review of Teaching, 1900, p. 16). I. A. Linnichenko paid special attention to the problem of “interpretation”, an explanation of the source, hermeneutics in all its manifestations. He was the author of a large array of works (about 400 ones), among which the research in special historical disciplines is of considerable interest: archeography, source criticism, historical bibliography, historiography (DAOO. F. 153. Inv. 1. F. 88. PP. 1–3). The scholar was a corresponding member of the St. Petersburg Academy of Sciences, and made many successful addresses at international congresses. During the Civil War, I. A. Linnichenko continued to teach at the Imperial Novorossiya University; in January 1920, together with the retreating units of the White Army, he left Odesa and moved to the Crimea. In the last years of his life, I. A. Linnichenko worked at the Taurida University in Simferopol, continuing to engage in scientific activities.

At the beginning of the twentieth century, E. P. Trifiliev (1867–1928) was appointed an Extraordinary Professor of the department of Russian history at the Imperial Novorossiya University. A graduate of the Kharkiv University, where his historical views were formed under the influence of professors D. I. Bagaley and P.N. Butsinsky, he worked for some time as an Assistant Professor at the university in Kharkiv. In 1906, E. P. Trifiliev, under the leadership of P. N. Butsinsky, prepared and defended his magister's thesis on the history of the peasantry during the reign of the Emperor Paul I. This defense opened the way for the scientist to the Imperial Novorossiya University, where he began teaching in the spring of 1911.

E. P. Trifiliev taught at the Department of Russian History a general course on Russian history; a special course "History of serfdom in Russia", which he paid attention to the analysis of sources (The Review of Teaching, 1915, p. 13). His main articles and monographs are written from a positivist standpoint. E. P. Trifiliev's undoubted merit was the introduction into scientific circulation of a significant complex of documentary sources from the funds of the central and local archives. After the establishment of the Soviet power, the scientist continued his teaching activities, participated in the reformation of higher education in Odesa, and took a prominent place among Odesa historians.

During this period, the disciplines read by the privat-docents (later, they became professors) A. V. Florovsky and V. E. Krusman are of considerable interest. A. V. Florovsky, reading the course "Review of Monuments of Russian Legislation", focused on the features of the analysis of act materials, and V. E. Krusman developed a methodological course "A General Theory of History", where he paid special attention to the issues of working with historical sources (The Review of Teaching, 1915, p. 13). It should be noted that at the beginning of the XX century the number of courses in source studies at the Faculty of History and Philology of The Novorossiya University had increased markedly.

Summing up, we can state that it was in the second half of the XIX – early XX century, at The Novorossiya University, in line with the subjects taught by the teachers of the departments of general and Russian history, the foundations of science knowledge about sources and their use in historical research were gradually formed.

Conclusions.

Thus, at the Imperial Novorossiya University, the process of the development of source criticism as a scientific discipline was intensively going on. A scientific discipline develops under the influence of various factors of an intellectual and sociocultural nature, and a real practice requires the demarcation and allocation of a new type of cognitive activity into a separate branch of knowledge. This is a complex and time-consuming process that proceeded in different ways at the universities of the Russian Empire. If at the end of the XIXth century at the Kyiv and Moscow universities, the source studies had been lectured, then at the Imperial Novorossiya University at the beginning of the twentieth century the process of its separation has not yet been completed. At the same time, in the practice of teaching, the need to separate the study of source from the total mass of taught history courses into a separate scientific discipline became more and more obvious. That process had a solid foundation: all professors-historians, while preparing their dissertations, based on a representative source base, introduced an array of published and archived historical sources into scientific circulation, expanded them into further scientific activities. The University teachers transferred their knowledge and skills in the field of working with sources to students during the faculty classes.

A number of stages can be traced in the formation of source criticism at the Imperial Novorossiya University. The first stage covers the first decade of the history of the university – 1865–1875, when teachers in their courses tried to convey to students a general knowledge about the sources and their significance for historical research. At the second stage (1876–1890), a system of training workshops was established at the university, during which students got acquainted with certain types and kinds of sources. The third stage covers the period of 1891–1920 years and it may be characterized by an increase in the number of source criticism workshops, where methods of working with sources were improved, and the formation of source criticism courses.

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Становлення основ джерелознавства як наукової дисципліни в Імператорському Новоросійському університеті

Анотація. *Стаття присвячена дослідженню становлення джерелознавчих знань у відкритому в другій половині XIX ст. в Одесі Імператорському Новоросійському університеті. Спираючись на комплекс загальнонаукових, історичних і джерелознавчих методів автори на основі аналізу викладацької діяльності професорів та доцентів історико-філологічного факультету розкрили етапи становлення джерелознавства в процесі викладання історичних дисциплін в університеті. У статті формування основ джерелознавства розглядають як складний процес, який в західноєвропейській і вітчизняній науці став результатом розвитку теорії та практики повсякденного діалогу вчених з історичними джерелами. Цей процес мав великий вплив на розвиток університетської історичної освіти, що, як показано в статті, було одним з важливих чинників формування джерелознавства як наукової дисципліни. Історію окремо взятих наукових дисциплін не можна зрозуміти поза контекстом розвитку науки в цілому, тому автори приділили увагу зміні наукових парадигм в досліджуваний період. Відзначається, що реформи в сфері освіти і розвиток європейського історичного знання стали основними складовими формування вчених-істориків, які своєю науковою діяльністю на теоретичному і практичному рівні сприяли становленню спеціальних історичних дисциплін. У статті виявлено поступове збільшення на історичному відділенні історико-філологічного факультету числа курсів, що читалися, в яких викладачами використовувалася можливість навчити студентів працювати з різними типами і видами джерел. Авторами розглядається внесок істориків Одеси XIX – початку XX ст. в процес*

інституалізації історичних дисциплін, в формування комплексу спеціальних історичних дисциплін, наслідком чого стала актуалізація їх наукових праць в наступні роки. В результаті дослідження автори прийшли до висновків, що професори кафедр загальної та російської історії своєї викладацькою та науковою діяльністю заклали основи джерелознавства як спеціальної наукової дисципліни, піднімаючи в лекційних курсах теоретичні проблеми, а на практикумах, навчаючи студентів практичній роботі з джерелами.

Ключові слова: *історичні джерела; професори; студенти; спеціальні історичні дисципліни*

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Становление основ источниковедения как научной дисциплины в Императорском Новороссийском университете

Аннотация. *Статья посвящена исследованию становления источниковедческих знаний в открытом во второй половине XIX ст. в Одессе Императорском Новороссийском университете. Опираясь на комплекс общенаучных, исторических и источниковедческих методов авторы на основе анализа преподавательской деятельности профессоров и доцентов историко-филологического факультета раскрыли этапы становления источниковедения в процессе преподавания исторических дисциплин в университете. В статье формирование основ источниковедения рассматривают как сложный процесс, который в западноевропейской и отечественной науке стал результатом развития теории и практики повседневного диалога ученых с историческими источниками. Этот процесс имел большое влияние на развитие университетского исторического образования, которое, как показано в статье, являлось одним из важных факторов формирования источниковедения как научной дисциплины. Историю отдельно взятых научных дисциплин нельзя понять вне контекста развития науки в целом, поэтому авторы уделили внимание смене научных парадигм в исследуемый период. Отмечается, что реформы в сфере образования и развитие европейского исторического знания стали основными составляющими формирования ученых-историков, которые своей научной деятельностью на теоретическом и практическом уровне способствовали становлению специальных исторических дисциплин. В статье выявлено постепенное увеличение на историческом отделении историко-филологического факультета числа читаемых курсов, в которых преподавателями использовалась возможность научить студентов работать*

с различными типами и видами источников. Авторами рассматривается вклад историков Одессы XIX – начала XX ст. в процесс институализации исторических дисциплин, в формирование комплекса специальных исторических дисциплин, следствием чего стала актуализация их научных трудов в последующие годы. В результате исследования авторы пришли к выводам, что профессора кафедр общей и русской истории своей преподавательской и научной деятельностью заложили основы источниковедения как специальной научной дисциплины, поднимая в лекционных курсах теоретические проблемы, а на практикумах, обучая студентов практической работе с источниками.

Ключевые слова: *исторические источники; профессора; студенты; специальные исторические дисциплины*

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Evolution of teaching the probability theory based on textbook by V. P. Ermakov

Abstract. *The paper is devoted to the study of what changes the course of the probability theory has undergone from the end of the 19th century to our time based on the analysis of The Theory of Probabilities textbook by Vasyl P. Ermakov published in 1878. In order to show the competence of the author of this textbook, his biography and creative development of V. P. Ermakov, a famous mathematician, Corresponding Member of the St. Petersburg Academy of Sciences, have been briefly reviewed. He worked at the Department of Pure Mathematics at Kyiv University, where he received the title of Honored Professor, headed the Department of Higher Mathematics at the Kyiv Polytechnic Institute, published the Journal of Elementary Mathematics, and he was one of the founders of the Kyiv Physics and Mathematics Society. The paper contains a comparative analysis of The Probability Theory textbook and modern educational literature. V. P. Ermakov's textbook uses only the classical definition of probability. It does not contain such concepts as a random variable, distribution function, however, it uses mathematical expectation. V. P. Ermakov insists on excluding the concept of moral expectation accepted in the science of that time from the probability theory. The textbook consists of a preface, five chapters, a synopsis containing the statements of the main results, and a collection of tasks with solutions and instructions. The first chapter deals with combinatorics, the presentation of which does not differ much from its modern one. The second chapter introduces the concepts of event and probability. Although operations on events have been not considered at all; the probabilities of intersecting and combining events have been discussed. However, the above rule for calculating the probability of combining events is generally incorrect for compatible events. The third chapter is devoted to events during repeated tests, mathematical expectation and contains Bernoulli's theorem, from which the law of large numbers follows. The next chapter discusses conditional probabilities, the simplest version of the conditional mathematical expectation, the total probability formula and the Bayesian formula (in modern terminology). The last chapter is devoted to the Jordan method and its applications. This method is not found in modern educational literature. From*

the above, we can conclude that the probability theory has made significant progress since the end of the 19th century. Basic concepts are formulated more rigorously; research methods have developed significantly; new sections have appeared.

Keywords: *history of mathematics; definition of probability; axiomatic approach; mathematical expectation*

Introduction.

The Ukrainian school of the probability theory is widely known in the world. It includes such outstanding mathematicians as I. I. Gikhman, A. V. Skorokhod, V. S. Korolyuk. Successful research is carried out in such areas as the theory of random processes, stochastic differential equations, queuing theory, reliability theory, etc. But along with the development of the probability theory, its teaching could not but change.

In the 19th century, the probability theory began to gradually transform from a collection of individual problems into a mathematical theory with a fairly clearly outlined problematic. However, during this period, it was more related to applied mathematics. In particular, Hilbert, in his speech at the International Congress of Mathematicians in Paris (1900), referred the probability theory together with mechanics to the physical sciences (Kolmogorov & Yushkevich, 1978, p. 240).

Let us recall how the presentation of the probability theory took place in the 19th century in some European countries.

In Great Britain, the probability theory was one of the first to be expounded by institutions related to insurance. In 1857, the Institute of Actuaries offered a ten-week course “Theory of life contingencies” for two guineas (Flood, Rice, & Wilson, 2011, p. 264).

In France, the probability theory was to be included in the course of mathematics, which Lacroix began teaching at the Lyceum in 1786. Interest rates, mortality tables, theory of combinations, etc. were to be considered. However, in 1787, due to a shortage of students, the classes stopped. Since that time, courses in probability theory have repeatedly appeared and disappeared. In particular, from 1819 to 1830, Arago taught a course in social arithmetic at the Ecole Polytechnique, which studied the general principles of defining the probability theory, the application of probabilities to calculating payments in lotteries, the mortality table, cumulative interest, annuities, insurance, etc.

Subsequently, the course was supplemented by Bernoulli's theorem. In subsequent years, the economic and social components were reduced, and in the 1840s, the course was simplified. In particular, Bernoulli's theorem was excluded from it (Meusnier, 2006).

In the Czech Republic, the probability theory was first included in a school textbook in 1870. It was Josef Smolik's textbook. Probability theory was 10 pages long and covered questions related to combinatorics.

The terminology had nothing to do with modern terminology. Also, the probability theory in the same volume was considered in the textbook by Studnichka for the higher grades, where, in addition to tasks related to combinatorics, there were also simple tasks for life insurance (Mačák, 2005, p. 14–15).

By the beginning of the 20th century, when interest in actuarial mathematics and mathematical statistics grew, probability theory was taught sporadically at universities in the Czech Republic and Austria. In some technical universities in the middle of the 19th century, the "political arithmetic" was studied (Bilová, Mazliak, & Šišma, 2006, pp. 3–4). It is believed that Doppler and Matzka were the first to expound the probability theory in higher educational institutions of the Czech Republic in the middle of the 19th century (Mačák, 2005, p. 14). In the 1870s, Panek taught a course at the Czech Polytechnic University containing absolute, relative, and complex probability, geometric probability, Bernoulli's theorem and Poisson's theorem, objective and subjective expectations, posterior probability, the Bayesian formula, Laplace's theorem, insurance, the historical overview of the computation of probabilities, and the method of least squares (Bilová, Mazliak, & Šišma, 2006, pp. 4–5).

In Berlin between 1829 and 1850, Dirichlet gave nine courses of lectures on the probability theory and its application to the theory of errors, in particular to the method of least squares. In these lectures, problems related to the duration of the game, Stirling's formula, the probability of hypotheses, Bernoulli's theorem, the central limit theorem, estimates of the distribution of medians, geometric probability (Fischer, 1994, pp. 40–42).

In the territory of the Russian Empire, the course of probability theory was first taught in 1829 by Zygmund Revkovsky at Vilnius University. There was no textbook in Russian at that time and therefore, he not only developed the course himself, but also introduced his own terminology. In 1849, Professor Bayer began teaching the probability theory at Kharkiv University. In 1850 V. Ya. Bunyakovsky began to give a course in probability theory at Moscow University and in 1857, such a course appeared at St. Petersburg University. In other Russian universities in the middle of the 19th century, this course was not given (Kletska, 2016, p. 125).

At the Kyiv University of St. Vladimir, the probability theory was first given by M. Ye. Vaschenko-Zakharchenko in 1863 (Kletska, 2016, p. 126).

In Russia, the first textbook on the probability theory *The Foundations of the Mathematical Probability Theory* (1846) belonged to V. Ya. Bunyakovsky. This textbook covered not only the theory, but also the history of the emergence and development of the probability theory. It provided an explanation for problem solving and indicated many practical applications. And the first in Ukraine a textbook on the probability theory was published in 1878 by Prof. V. P. Ermakov, a student and colleague of Vaschenko-Zakharchenko (Kletska, 2016, pp. 125–126).

The purpose of this paper is to study the changes that the course of probability theory has undergone since the publication of V. P. Ermakov's textbook *The Probability Theory* (Ermakov, 1879) to the present.

Research methods.

The paper uses a comparative analysis of *The Probability Theory* by V. P. Ermakov and textbooks of the second half of the 20th century and the beginning of the 21st century on probability theory for students of higher educational institutions.

Results and discussion.

Review of the biography of V. P. Ermakov.

Before proceeding to discuss the textbook and to compare it with other literature, we should make sure of the competence of the author.

Vasyl Petrovych Ermakov is an outstanding mathematician, author of about 150 papers, Corresponding Member of the St. Petersburg Academy of Sciences, Professor at Kyiv University, first Head of the Department of Higher Mathematics at Kyiv Polytechnic Institute. He worked in areas such as the theory of series, variational calculus, differential equations, the theory of special functions, algebra, and the theory of numbers. In particular, he owns one of the most important results in the theory of series – a very sensitive criterion for the convergence of series with integral terms.

Vasyl Petrovych was born on February 27 (March 11), 1845, in the village of Teryukha, near Gomel.

He received his primary education at the parochial school where his father taught. He then studied at Gomel Gymnasium and then at Chernihiv Gymnasium. In 1864, he entered Kyiv University in the Mathematical Department of the Faculty of Physics and Mathematics (Dobrovolsky, 1981, p. 6).

In 1871, Ermakov introduced a new test of the convergence of series, which bears his name and made him known to the mathematical community. In 1873, he defended his thesis on “The General Theory of Integration of Linear Differential Equations of Higher Orders with Partial Derivatives and Constant Coefficients”. In 1874, Ermakov was elected Assistant Professor of the Department of Pure Mathematics at Kyiv University. Also, from 1871, for several years, he taught at the Kyiv Women's Gymnasium; from 1874 to 1880, he was a teacher at a military gymnasium and also taught geometry at the Higher Women's Courses (Dobrovolsky, 1981, pp. 19, 23–25).

On September 13, 1877, V. P. Ermakov defended his thesis for a doctorate on the topic “Integration of Differential Equations of Mechanics”. Soon he received the title of Extraordinary Professor and in 1884, he was elected a Corresponding Member of the St. Petersburg Academy of Sciences. In 1888, Vasyl Petrovych received the

title of Ordinary Professor and in March 1899, he received the title of Honored Professor and was transferred to Extraordinary Professor.

In August 1898, Ermakov was invited to the Department of Higher Mathematics of the newly organized Kyiv Polytechnic Institute, which he headed, leaving himself in the service at the University. In 1884–1886, he published the *Journal of Elementary Mathematics*. He became one of the organizers of the Kyiv Physics and Mathematics Society.

In 1909, due to his advanced age and deteriorating health, Ermakov completely transferred to the Polytechnic Institute, where he continued to work until February 21, 1919 (Gratsianskaia, 1956, pp. 675–679).

On March 16, 1922, Vasyl Petrovych Ermakov died.

A. P. Psheborskyi recalled, "V. P. as a Professor enjoyed deep respect and great love. In his relations with students, he was harsh and rude sometimes, but, at the same time, extremely gentle and forgiving, so a lot, or rather everything, was forgiven "Vasyl", as the students called him among themselves in my time. Everyone knew that he would always find warm support from V. P. in his scientific work" (Psheborskyi, 1922).

At Kyiv University and KPI, Ermakov taught such subject matters as probability theory, partial differential equations, ordinary differential equations, theory of vectors in the plane, analytical geometry, spherical trigonometry, etc. Based on these courses, he wrote a large number of textbooks, the hallmarks of which were clarity and ease of presentation (Gratsianskaia, 1956, p. 676).

The Probability Theory ("Теорія вѣроятностей") by Ermakov is considered to be the first textbook on the probability theory in Ukraine. It was first published in 1878 in Izvestia of Kyiv University; a year later, it came out as a separate edition; and 23 years later, it was republished using lithography (Gnedenko & Gikhman, 1956, p. 485).

Thus, V. P. Ermakov is worth a detailed study. Let us analyze, using his example, how the teaching of this science has changed since then and up to the present.

Using definitions of probability.

The modern probability theory is based on the axiomatic approach of A. M. Kolmogorov and, thus, relies heavily on set theory and measure theory. In particular, the mathematical expectation is the Lebesgue integral.

The axiomatic definition is used in educational literature of the late 20th and early 21st century for physical and mathematical specialties (Shiryaev, 1979; Kartashov, 2008; Gnedenko, 1988; Seno, 2007). Other textbooks limit themselves to the use of classical, geometric, and statistical definitions of probability.

In Ermakov's book, only the classical definition is used. The axiomatic approach, of course, cannot be mentioned, since it was formed later. No statistical definition is used.

The geometric definition is not mentioned in the book, although it was known by that time. In particular, it was included in the curriculum of the course that Dirichlet taught in 1838 (Fischer, 1994, p. 42). But does Ermakov really not consider the problems associated with an infinite number of elementary events? He gives the following problem, "The rod is broken at random into three parts; what is the probability that these three pieces can make a triangle?" Vasyl Petrovych emphasizes that in this problem both the number of all and the number of favorable elementary events called cases are infinite, but he does not introduce additional definitions, but solves the problem using the passage to the limit. He proposes to split the rod into *2n* equal parts and to assume that the rod can only break at the points of division. Denoting the lengths of the formed pieces by *x*, *y* and *z=2n-x-y*, he obtains the inequalities

$$\begin{aligned} x &< n, \\ y &< n, \\ x + y &> n. \end{aligned} \qquad (1)$$

Analyzing the number of solutions to this system in natural numbers, he obtains the probability $\frac{n-2}{4n-2}$ for the discrete model, and then, using the passage to the limit, finds the required probability $\frac{1}{4}$ (Ermakov, 1879, pp. 29–30).

Thus, unlike modern authors, V. P. Ermakov limited himself in his textbook to only the classical definition of probability.

The structure and subject of the textbook.

Textbooks of the late 20th and early 21st century on the probability theory differ greatly depending on the audience for which they are intended. Thus, textbooks for students of physics and mathematics specialties may contain sections such as Markov's chains (for example, (Shiryaev, 1979; Kartashov, 2008; Gnedenko, 1988; Seno, 2007), martingales (Shiryaev, 1979; Kartashov, 2008), stationary sequences (Shiryaev, 1979), etc. However, usually the elementary probability theory (Shiryaev, 1979; Gnedenko, 1988; Seno, 2007; Gmurman, 2004), which includes the classical and geometric definition of probability, is considered first, and then the axiomatic definition is introduced (in the literature for students of physical and mathematical specialties, for example, (Shiryaev, 1979; Kartashov, 2008; Gnedenko, 1988; Seno, 2007), the concept of a random variable and related concepts such as the distribution function, distribution density, mathematical hope, characteristic function. Further, the authors move on to more complex sections, which may include limit theorems, elements of the theory of random processes, etc. Often textbooks, along with the probability theory, also contain mathematical statistics (Kartashov, 2008; Gnedenko, 1988; Seno, 2007; Gmurman, 2004; Kushlyk-Dyvulska, Polishchuk, Orel, &

Shtabaliuk, 2014; Sliusarchuk, 2005; Klesov, 2010; Yezhov, 2001; Rabyk, 2004; Gorban & Snizhko, 1999).

V. P. Ermakov's textbook contains only the probability theory without mathematical statistics. It consists of a preface, five chapters, a synopsis, and problems with answers. The first chapter is devoted to combinatorics and Newton's binomial. In the second chapter, the concept of the probability of an event is introduced and the techniques for determining the probabilities of unification and intersection (in modern terminology) of events have been considered. In the third chapter, the probabilities of events in repeated tests have been examined, Bernoulli's theorem has been proved, and the concept of mathematical expectation has been introduced. The fourth chapter is devoted to conditional probabilities. The fifth chapter discusses the Jordan method and its application. In the synopsis of the probability theory, in less than six pages, the basic concepts and results of the book have been formulated. Finally, at the end of the textbook, there are 61 self-instructional tasks and answers or hints to each of these tasks.

Thus, in this textbook, there is not even the concept of a random variable and, therefore, there are no distribution functions, characteristic functions, but there is a concept of mathematical expectation.

According to the modern definition, the mathematical expectation of a random variable is introduced as the Lebesgue integral

$$\int_{\Omega} \xi(\omega) d\, P(\omega) \qquad (2)$$

over the probability measure. Usually, it is denoted by $M\xi$ or $E\xi$.

Since students of many specialties do not study the Lebesgue integral, in their textbooks, the authors have to avoid this concept and introduce separate definitions of the mathematical expectation for discrete and continuous random variables (Gmurman, 2004; Kushlyk-Dyvulska, Polishchuk, Orel, & Shtabaliuk, 2014; Klesov, 2010; Yezhov, 2001; Rabyk, 2004; Gorban & Snizhko, 1999). In particular, for a discrete random variable, the mathematical expectation is the sum of the products of all its values by the corresponding probabilities.

It is this approach that Ermakov uses in his book. Instead of a random variable, he considers "a certain quantity x that can acquire different values, depending on which of the events will occur during observation". And the mathematical expectation is introduced as "the sum of the products of the probability of each event that can occur during a given observation, by the value acquired by the unknown when this event occurs" (Ermakov, 1879, pp. 64–65).

In addition to the simplest properties of the mathematical expectation, Ermakov considers the simplest version of the conditional mathematical expectation, although he does not use this term. He pays great attention to examples of harmless games, that is, those in which the mathematical expectation of the player's payoff is equal to zero.

Ermakov also recalls the concept of moral expectation, which was used in the probability theory of that time. It was suggested by Daniel Bernoulli to address questions about the harmlessness of games. At the same time, Bernoulli and subsequent researchers reasoned as follows: if the poor man and the rich one can receive the same amount of money with the same probabilities, then, although the mathematical expectations of their profits are equal, the moral expectations are different, since in reality, the moral satisfaction of the poor man is much greater than the satisfaction of the rich one. That is, when calculating the moral expectation, the player's property is also taken into account. Ermakov insists on removing the concept of moral expectation from the probability theory, because, firstly, it is difficult to establish an exact measure for determining moral pleasure, and secondly, if a game, according to the theory of moral expectation is harmless for one player, it is disadvantageous for his opponent (Ermakov, 1879, p. 78). Indeed, the concept of moral expectation has disappeared from the probability theory and it is not found in modern textbooks.

Also in Ermakov's book, there are no concepts of variance and the random variable itself.

Let's consider in more detail the contents of each chapter of the book.

As mentioned, the first chapter is about combinatorics. It deals with permutations and combinations. At the same time, notation, results, and methods of proof are not very different from modern ones, except that the notion of factorial is not introduced. Some properties are proved in several ways, but the geometric interpretation of the combinations is not used. Further, Ermakov considers Newton's binomial. He not only gives and proves the Newton binomial formula and some properties of binomial coefficients in two ways, but also considers a binomial series with a negative integer exponent, proves the convergence, and finds the sum of this series. He calls a suitable formula Newton's formula with a negative exponent. Also in the first chapter, complex auxiliary formulas for binomial coefficients, which will be used in other sections, have been deduced. The second chapter introduces the concept of probability using the classical definition. In this case, the concept of an incident is introduced intuitively, "Everything that happens in nature is called a *phenomenon*. Each phenomenon leads to many *occurrences*; in some of these cases, one *event* occurs, in others another one" (Ermakov, 1879, p. 21).

No operations on events are formally introduced, but the probability that two events occur is being investigated. In particular, the probability of an intersection of independent events is being investigated, "The probability of a complex event consisting of the simultaneous occurrence of several independent events is equal to the product of the probabilities of simple events" (Ermakov, 1879, p. 34). In this case, the concept of independent events is introduced as follows: events are considered independent of each other if "the probability of each event does not depend on whether other events have occurred or not" (Ermakov, 1879, p. 40). For comparison, in modern probability theory, two events are called independent if

$$P(A \cap B) = P(A) \cdot P(B). \quad (3)$$

As for the probability addition theorem, the textbook by V. P. Ermakov states, "The probability that one of several events will occur is equal to the sum of the probabilities of these events" (Ermakov, 1879, p. 118). This statement is generally incorrect, as it is true in the case of incompatible events. For two compatible event A and B , the probability that at least one of them will occur is by the formula

$$P(A \cup B) = P(A) + P(B) - P(A \cap B). \quad (4)$$

There are also probabilities that the event will take place for the first time in the k trial or will not take place at all in the series. In practice, conditional probabilities are already in use, although this term is not used either, "The probability of a complex event, consisting of the occurrence of any events, is equal to the product of several factors, the first factor of which expresses the probability of the first event, the second factor – the probability of the second event calculated on the assumption that the first event has already occurred, the third factor – the probability of the third event calculated under the assumption that the first two events have already occurred, etc." (Ermakov, 1879, p. 117).

The third chapter is devoted to the events during retests and the mathematical expectation, which was already mentioned in detail above. Both Bernoulli's scheme and Bernoulli's theorem have been considered.

In modern textbooks, much attention is paid to limit theorems, especially to those designed for students of physics and mathematics specialties. Boundary theorems include various forms of the law of large numbers and the central boundary theorem. In textbooks for students of physical and mathematical specialties, such as (Shiryaev, 1979, p. 385), the law of the iterated logarithm has been also considered, which occupies an intermediate position between these theorems.

Bernoulli's theorem was first proved by Jacob Bernoulli at the end of the 17^{th} century. The textbook uses the method proposed by Chebyshov to confirm a more general result, from which Bernoulli's theorem follows as a special case. It is to prove this theorem that the auxiliary formulas given in the first chapter are used. Ermakov formulates it as follows, "The probability that the ratio of the number showing how many times an event occurred in m tests to the total number of tests differs from the probability of the event by an amount not exceeding ε, lies in the range from $1-\frac{pq}{\varepsilon^2 m}$ to 1, where p is the probability of the event, and $q=1-p$" (Ermakov, 1879, pp. 118–119). From this, he concludes that this ratio, with an increase in the number of trials, coincides with the probability of an event. Thus, his textbook contains the law of large numbers with proof.

But the central limit theorem is not mentioned in Ermakov's book and it cannot be mentioned, since it does not use the very concept of a random variable distribution.

The next chapter examines the probabilities that are called conditional in modern terminology. In fact, the formula of total probability and the Bayesian formula have been given, and the simplest kind of conditional mathematical expectation has been also considered.

The last fifth chapter is unusual for the modern reader. It considers such a class of problems. "Suppose some experience leads to several events; we will specifically choose from these events the following:

$$E_1,\ E_2,\ E_3,\ \ldots\ E_m \tag{5}$$

and show how to solve such issues:

1) How likely is it that *r* events (5) will appear?
2) How likely is it that there will be *r* or more events (5)?
3) How likely is it that none of the events (5) will occur?
4) How large is the average number of events (5) that have appeared?" (Ermakov, 1879, p. 100).

V. P. Ermakov notes that such problems are quite diverse. Many have been solved, but separate methods were used for all these tasks. He also gives the general method proposed by Jordan. Based on the results of the first chapter, with formulas for the binomial series inclusive, answers to all the above questions have been given, namely, the probability that *r* events from (5) class will occur is

$$U_r = Q_r - \frac{r+1}{1} Q_{r+1} + \frac{(r+1)(r+2)}{1\cdot 2} Q_{r+2} - \cdots, \tag{6}$$

where Q_r – the sum of the probabilities of all possible events, consisting in the fact that *r* selected events from (5) class are coming (Ermakov, 1879, p. 103). The rest of the tasks are solved in a similar way. The application of these formulas has been demonstrated for a large number of tasks.

The textbook contains a huge number of tasks to be solved. It also ends with a collection of tasks, to which instructions and answers are given. Interestingly, some of these tasks have already been discussed in detail in the main part of the book.

Discussion.

The Probability Theory by V. P. Ermakov was one of the most modern textbooks by the time of its release (Kletska, 2016, p. 126).

The situation with educational literature at the end of the 19th century in the Russian Empire was very difficult. The course of the probability theory was just being introduced into university programs and lecturers and students had only the textbook by Bunyakovsky, which could not be called an elementary one. True, in 1857 *The Application of the Probability Theory in Calculating Observations and*

Geodetic Measurements by A. N. Savych was published, but it pursued other goals and it could not be a textbook on the probability theory. Therefore, the appearance of the textbook by V. P. Ermakov was an outstanding event (Gnedenko & Gikhman, 1956, pp. 484–485).

B. V. Gnedenko and I. I. Gikhman (1956, p. 486) believed that there are many logical and methodological mistakes in it, much was taken as obvious, although in fact, it required detailed consideration, but it was a step forward compared to other courses, as the author tried to acquaint the reader with the main achievements of that time, illustrating them with many examples. They appreciate this textbook, although they point out the following shortcomings. When defining probability as the ratio of the number of favorable cases to the number of all possible ones, Ermakov does not indicate that such a definition requires the requirement that all cases are equally possible. When formulating the multiplication theorem, he does not indicate that it comes true only for independent events and the very concept of independence appears only 6 pages later. The addition theorem is formulated without requiring the incompatibility of events. Also, the independence requirement is absent in the formulation of Bernoulli's theorem.

Conclusions.

From the end of the 19th century to the beginning of the 21st century, the course of probability theory underwent great changes and these changes have influenced even the very concept of probability. An axiomatic approach has appeared, the definition has become clearer and more formalized, and such insufficiently clear concepts as moral expectation have disappeared. Using clear axiomatics, it was possible to introduce such concepts as a random variable, a distribution function, to implement powerful research methods, for example, the method of characteristic functions. Due to the fact that many new sections have appeared, some of the results and methods are no longer studied, as happened, in particular, with the Jordan method.

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Еволюція викладання теорії ймовірностей на основі підручника В. П. Єрмакова

Анотація. *Стаття присвячена дослідженню, яких змін зазнав курс теорії ймовірностей з кінця XIX століття до нашого часу, на прикладі аналізу підручника Василя Петровича Єрмакова "Теорія ймовірностей", опублікованого в 1878 році. Щоб показати компетентність автора цього підручника, коротко розглянуто біографію й творчий шлях В. П. Єрмакова, відомого математика, члена-кореспондента Петербурзької Академії наук. Він працював на кафедрі чистої математики Київського університету, де згодом отримав звання заслуженого професора, очолював кафедру вищої математики Київського політехнічного інституту, видавав "Журнал елементарної математики", був одним з організаторів Київського фізико-математичного товариства. Стаття містить порівняльний аналіз його підручника "Теорія ймовірностей" і сучасної навчальної літератури. Підручник В. П. Єрмакова використовує тільки класичне визначення ймовірності. Він не містить таких*

понять, як випадкова величина, функція розподілу, проте використовує математичне сподівання. В. П. Єрмаков наполягає на виключенні з теорії ймовірностей поняття морального сподівання, прийнятого в науці того часу. Підручник складається з передмови, п'яти глав, конспекту, в якому зібрані формулювання основних результатів, і збірки завдань з розв'язаннями та вказівками. У першому розділі розглядається комбінаторика, виклад якої не сильно відрізняється від її сучасного. У другому розділі вводяться поняття події і ймовірності. Хоча операції над подіями не розглядаються зовсім, розглянуто ймовірності перетину й об'єднання подій. Проте вказане правило для обчислення ймовірності об'єднання подій, взагалі кажучи, невірне для сумісних подій. Третя глава присвячена подіям при повторних випробуваннях, математичному сподіванню та містить теорему Бернуллі, з якої випливає закон великих чисел. У наступному розділі розглядаються умовні ймовірності, найпростіший варіант умовного математичного сподівання, формула повної ймовірності та формула Баєса (в сучасній термінології). Остання глава присвячена методу Жордана і його застосуванням. У сучасній навчальній літературі цей метод не зустрічається. З вищевикладеного можна зробити висновок, що теорія ймовірностей з кінця XIX століття значно просунулася вперед. Більш строго формулюються основні поняття, істотно розвинулися методи дослідження, з'явилися нові розділи.

Ключові слова: *історія математики; означення; аксіоматичний підхід; математичне сподівання*

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Эволюция преподавания теории вероятностей на основе учебника В. П. Ермакова

Аннотация. *Статья посвящена исследованию, как изменился курс теории вероятностей с конца XIX века до наших дней, на примере анализа учебника Василия Петровича Ермакова "Теория вероятностей", опубликованного в 1878 году. Чтобы показать компетентность автора этого учебника, кратко рассмотрены биография и творческий путь В. П. Ермакова, известного математика, члена-корреспондента Петербургской Академии наук. Он работал на кафедре чистой математики Киевского университета, где со временем получил звание заслуженного профессора, возглавлял кафедру высшей математики Киевского политехнического института, издавал "Журнал элементарной математики", был одним из организаторов Киевского физико-математического общества. Статья содержит сравнительный анализ его учебника "Теория вероятностей" и современной учебной литературы.*

Учебник В. П. Ермакова использует только классическое определение вероятности. Он не содержит таких понятий, как случайная величина, функция распределения, но тем не менее использует математическое ожидание. В. П. Ермаков настаивает на исключении из теории вероятностей понятия нравственного ожидания, принятого в науке того времени. Учебник состоит из предисловия, пяти глав, конспекта, в котором собраны формулировки основных результатов, и сборника задач с решениями и указаниями. В первой главе рассматривается комбинаторика, изложение которой не сильно отличается от современного. Во второй главе вводятся понятия события и вероятности. Хотя операции над событиями не рассматриваются вовсе, рассмотрены вероятности пересечения и объединения событий. Однако, указанное правило для вычисления вероятности объединения событий, вообще говоря, неверно для совместных событий. Третья глава посвящена событиям при повторениях опыта, математическому ожиданию и содержит теорему Бернулли, из которой следует закон больших чисел. В следующей главе рассматриваются условные вероятности, простейший вариант условного математического ожидания, формула полной вероятности и формула Байеса (в современной терминологии). Последняя глава посвящена методу Жордана и его применениям. В современной учебной литературе этот метод не встречается. Из вышеизложенного можно сделать вывод, что теория вероятностей с конца XIX века значительно продвинулась вперёд. Более строго формулируются основные понятия, существенно развились методы исследования, появились новые разделы.

Ключевые слова: *история математики; определение вероятности; аксиоматический подход; математическое ожидание*

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The history of assisted reproductive technologies: from prohibition to recognition

Abstract. *The birth of children after infertility treatment of married couples with the help of assisted reproductive technologies has become a reality after many years of basic research on the physiology of reproductive system, development of oocyte's in vitro fertilization methods and cultivation of embryos at pre-implantation stages. Given the widespread use of assisted reproductive technologies in modern medical practice and the great interest of society to this problem, the aim of the study was to trace the main stages and key events of assisted reproductive technologies in the world and in Ukraine, as well as to highlight the activities of outstanding scientists of domestic and world science who were at the origins of the development of this area. The paper used historical methods to study and interpret the texts of primary sources and present scientific historical events. In addition, the current trends in assisted reproductive technologies are covered based on the results of our own, more than 30 years of experience in the field of reproductive biology and medicine, and the achievements of world scientists. As a result of the work, it has been shown that*

despite certain ethical and social biases, the discovery of individual predecessor scientists became the basis for the efforts of Robert Edwards and Patrick Steptoe to ensure birth of the world's first child, whose conception occurred outside the mother's body. There are also historical facts and unique photos from our own archive, which confirm the fact of the first successful oocyte in vitro fertilization and the birth of a child after the use of assisted reproductive technologies in Ukraine. Over the last 20 years, assisted reproductive technologies have continued to grow, addressing many other issues of reproductive potential preservation and infertility treatment. State of the art methods of assisted reproductive technologies include the development of cryopreservation method of gametes and embryos by vitrification, genetic screening of embryos in order to prevent the hereditary diseases transmission and embryo transfer with chromosomal abnormalities, the birth of a child "from three parents" in severe cases of mutations in the mitochondrial genome, etc.

Keywords: *reproductive cells; embryos; in vitro fertilization; first "test tube" child; demography; infertility treatment*

Introduction.

There is no other field of science as assisted reproductive technologies (ART) that have made such an impressive progress from prohibition to recognition, from investigation to clinical implementation. The rapid development of ART and related methods is determined by the social and scientific environment that contributes to its development.

Scientific knowledge was rapidly accumulated during every historical stage of ART development, and there was a transition from empirical to practical research methods.

The modern scientific world is aware of the widespread introduction of ART methods in clinical practice. Unfortunately, only two scientists are well-known, P. Steptoe (1913–1988) and embryologist R. Edwards (1925–2013), who for the first time in the world managed to successfully fertilize an oocyte outside the mother's body, transfer the embryo into the patient's uterine cavity and obtain pregnancy which resulted in the birth of the world's first "test tube" child – Louise Brown.

The purpose of the study was to trace the main stages and key events of ART in the world and in Ukraine, as well as to highlight the activities and figures of outstanding scientists of domestic and world science who were at the origins of the development of this area, and the current trends in ART.

Research methods.

The methodology of the research is based on the principles of historicism, continuity of ideas and discoveries of historical knowledge, and interpretation the texts of primary sources, present scientific historical events. The work carried out the systematization of scientific data obtained in the scientometric databases Medline, PubMed, Cochrane Database of Systematic Reviews.

Results and discussion.

Delving into the historical aspect, the scientific development of ART has begun after microscope invention by the Dutchman Antoni van Levenhuk (1632–1723) in 1677 who studied human sperm and first saw and described spermatozoa.

Artificial insemination is the first mention of an ART method, which dates back to 1783 when the Italian scientist Lazzaro Spallanzani (1729–1799) received offspring due to the artificial insemination of dog (Ariatti & Mandrioli, 1993). Only seven years later, the Scottish physician John Hunter (1728–1793) used this technology for infertility treatment of married couple. He injected the man's semen into the genital tract of his wife who became pregnant and gave birth to a healthy child (Wagoner, 2017).

We should also mention Walter Heape (1855–1929), zoologist and embryologist, professor of Cambridge University, Great Britain. He studied the reproductive function of mammals and first reported the case of rabbits` birth after embryo transfer from one animal to another (Biggers, 1991). The scientist conducted his experiments at his home in Prestwich. He transferred two fertilized eggs obtained from a female Angora rabbit to the upper end of the fallopian tube of a female Belgian hare. The experimental animal gave birth to four rabbits, two of the Belgian hare breed and two of the Angora breed.

Gregory Goodwin Pincus (1903–1967) was an American scientist who had continued the study of his English colleague. He studied the hormonal effects on the reproductive system of mammals. In 1934, he performed the first fertilization of a rabbit oocyte in vitro. In 1936 he published his discoveries after experiments with parthenogenetic activation of oocytes. The scientist retrieved the oocyte and placed it in a mixture of saline and sex hormone. The fertilized oocyte was then transferred to an unpaired female which soon gave birth. It is believed that this experiment was the beginning of the development of *in vitro* fertilization technology (Cohen et al., 2005).

John Rock (1890–1984) was a prominent Boston gynecologist who worked at Harvard University and made a serious attempt to achieve clinical success in fertilizing human oocytes outside the mother's body (Thompson, 2016). In 1948 he and Miriam Menken (1901–1992) have obtained hundreds of oocytes during operative interventions on the female pelvic organs. Week after week Menken followed the same procedure: obtaining oocytes from the follicles on Tuesday, adding sperm to them on Wednesday, praying on Thursday, and looking at the microscope again the next day. Every Friday, when she looked in the microscope, she saw only one unfertilized cell and a pile of dead spermatozoa. She performed it 138 times, more than six years. And, what an incredible coincidence, she managed to fertilize 138 oocytes *in vitro*. The results of their work were published in the journal *Science*. The vagaries of fate did not allow scientists to continue the experiment. The reproductive aim of that time was not to give birth but directed to prevent it. The main goal of scientists was to develop simple and convenient methods of contraception.

In 1959 Min Chueh Chang (1908–1991), a young Chinese reproductive researcher, received an undeniable evidence of *in vitro* fertilized oocyte (Yanagimachi, 2016). He has published more than 300 scientific articles on this research subject. Mature unfertilized oocytes were obtained from female albino rabbits which were injected with sheep pituitary extract. Spermatozoa used for fertilization were obtained from the uteri of albino females mated with albino males 12 hours earlier. Three to four hours after fertilization in a Carrel flask, the oocytes were transferred to another flask containing 50% heated serum in saline and cultured to reach the 4-cell stage. In total, 36 second day embryos were transferred to 6 surrogate females of black color, 4 of which gave birth to 15 albino rabbits.

One of Min Chueh Chang students shared an impressive story. Carrying out one of the experiments he observed the penetration of spermatozoa into the oocyte. The passing of spermatozoon through the Zona pellucida (ZP) of the mammalian oocyte has never been observed before. After a while, the student brought the teacher a draft of an article describing the experiment. After a careful reading and some remarks, the teacher crossing out his name in the line of authors emphasized the importance and participation of his student.

At the same time experiments on *in vitro* fertilization of human embryos were continuing in a private clinic in America. The attending physician had prepared Doris Del-Zio for embryo transfer. However, Vande Wiele, the Head of hospital, had considered the procedure to be very contradictory and forbade it because, in his view, it did not comply with his ethical and moral principles. He believed that ART technology required the resolution of legal issues and adherence to scientific standards of that time. Vande Wiele argued that the procedure violated federal regulations because it was non-sterile. In addition, the doctor suggested that the child after ART might have developmental disabilities which could later lead to parents lawsuits. The couple did file a lawsuit, Dr. Vande Ville caused severe physical and mental suffering for patients due to canceling the embryo transfer. They sued the clinic for $ 1.5 million.

However, not all clinics had such a biased attitude towards ART. Many scientists continued working. The pregnancy after transfer of *in vitro* cultured embryo was reported in 1973 by Australian scientists. Unfortunately, the pregnancy was terminated at an early stage of embryonic development (Kretzer et al., 1973).

At the same time, English gynecologist P. Steptoe and embryologist R. Edwards (Fig. 1) began a joint research on the *in vitro* fertilization of animal oocytes. However, most scientists were skeptical about the success of the development of human embryos outside the body. The main executor of these works was a nurse and embryologist J. Purdy (Steptoe, 2015).

The experimental developments of these scientists have reached clinical trials. P. Steptoe and R. Edwards tried to help infertile couples to have a child. However, most of their colleagues believed that the use of human sperm and oocytes was unethical and contrary to moral principles. The founders of reproductive medicine were denied of state funding for research. Meanwhile, the problem of infertile

marriage in the UK was gaining momentum. Patients hopefully participated in experimental cycles of ART.

Figure 1. Scientists who for the first time performed a successful *in vitro* fertilization of human oocyte: on the left side– obstetrician-gynecologist P. Steptoe (1913 –1988), on the right side – physiologist R.Edwards (1925 – 2013) (Wade, 2010).

In 1976 the number of failed treatment attempts already exceeded 500. In those early days of research, and in such an indifferent or even hostile environment, there were some groups of enthusiasts around the world who shared a strong belief in success despite the difficulties and untruths and the value of this new scientific field.

In 1977 a significant event occurred. After in vitro fertilization of the oocyte, the P. Steptoe`s research group received the first pregnancy, which unfortunately turned out to be ectopic, and on July 25, 1978, the treatment cycle ended with the birth of the world's first "test tube" child, a girl named Louise Joy Brown! (Steptoe & Edwards, 1976).

According to the WHO, more than 4 million children are in the world today who were born after ART. According to current statistics it is 2% of newborns (Faddy, Gosden M & Gosden R, 2018).

In 2010, Dr. R. Edwards was awarded the Nobel Prize in Physiology and Medicine for his contribution to the world's scientific achievements. Gynecologist P. Steptoe was not awarded this prize because he died on March 21, 1988.

However, scientists from Bourn Hall were not alone in their research. Several groups of scientists worked on the same problem.

In June 1980, the world's third child conceived by ART was born in Australia. Earlier, the Melbourne Clinic reported two early biochemical pregnancies, which were confirmed by elevated levels of chorionic gonadotropin, thus demonstrating that embryos fertilized *in vitro* can develop to the blastocyst stage *in vivo* and possibly initiate implantation (Lopata, Johnston, Hoult & Speirs, 1980).

In September 1981, ART pioneers from around the world gathered at a meeting in Bourn Hall, Cambridge. They discussed the efforts of Indian scientists to recognize

their leadership in *in vitro* fertilization developing. It became known that experiments have been conducted with primitive tools and a household refrigerator in India in October, 1978, resulting in the birth of a "test tube" child. This piece of news was widely reported by the media in India and abroad. However, the doctors' statement was appealed because most of their research was not published in peer-reviewed journals. Due to the lack of scientific evidence, India's leadership in ART is not recognized by the international scientific community.

The path of ART development in Ukraine was also thorny. In 1974, the Ministry of Health of the USSR granted permission for the development and implementation of ART methods in the clinical practice of medical institutions in Moscow, Kharkiv and Leningrad. Valentyn Ivanovych Hryshchenko, a Ukrainian scientist, prominent obstetrician-gynecologist, cryobiologist, cryomedicist, pedagogue, Academician of the National Academy of Sciences of Ukraine, doctor of medical sciences, professor, became the ideological inspirer and organizer of innovative research in Ukraine. At that time, Valentyn Ivanovych was the Head of Obstetrics and Gynecology Department of Kharkiv State Medical University. From 1976 to 1979, he was one of the advisers of World Health Organization (WHO) on the Special Program of Human Reproduction, and since 1980, a WHO expert. From 1983 to 2011 he was the director of the Institute for Problems of Cryobiology and Cryomedicine of the National Academy of Sciences of Ukraine (IPC&C of the NAS of Ukraine). Due to his enthusiasm and creative energy, the results of research have been successfully implemented in clinical practice.

Several scientists who were together with Academician Valentyn Ivanovych Hryshchenko at the origins of Ukrainian reproductive medicine: head of the laboratory for cryobiology of human reproductive system Ph.D. Fedir Vlasovych Dakhno; Reproductologist, Ph.D, senior researcher Volodymyr Ivanovych Pinyaev and embryologist-cryobiologist, Ph.D., senior researcher Natalia Nesterivna Chub (Fig. 2).

Figure 2. Scientists of IPC&C of the NAS of Ukraine who for the first time in Ukraine carried out an oocyte *in vitro* fertilization (Academician V. I. Hryshchenko – on the right, Ph.D. V. I. Piniaiev – in the middle, Ph.D. N. N. Chub – near the microscope) (Author's photo).

This scientific team successfully fertilized oocyte *in vitro* and saw embryo development for the first time in Ukraine on November 30, 1984. It should be noted that equipment and medical supplies were not produced in the USSR, one could only dream of purchasing abroad. They made all consumables themselves from improvised means. For example, they made chambers for incubation of embryos adapting devices from chemical laboratories. The desiccator was used for embryo culturing instead of a thermostat. Laboratory equipment for research was very scarce, for example, inaccessible special dishes for culturing embryos were replaced by glasses that were bought at a watch factory.

As a result of the joint work of Kharkiv scientists, the first Ukrainian "test-tube" child Katya Kulyova was born on March 19, 1991 (Fig. 3).

Figure 3. Katya Kulyova (the first Ukrainian "test tube" child) and F. V. Dakhno (gynecologist, head of the laboratory for cryobiology of human reproductive system in the IPC&C NAS of Ukraine) (Author's photo).

During the analysis of archival materials and primary records of research it was revealed that there was not only the scientific but also the emotional component of the research, which allowed to understand the importance of this event and to assess the efforts of scientists who tried to achieve this goal (Fig. 4).

30 years have passed since the birth of the first "test tube" child. During this period, we have seen the development of areas related to ART. Successful oocyte *in vitro* fertilization depends on many factors, one of which is the quality of the female and male gametes. It turned out that in case of male infertility, the efficiency of using the *in vitro* fertilization method existing at that time was very low. The main problem was that the spermatozoon could not penetrate the thick ZP shell of oocyte. Thus, a new method of *in vitro* fertilization has been invented. Embryologists began using methods which increase softening of *ZP* (Kiessling, Loutradis, Mcshane & Jackson,

1988), creating a hole in it with an acidic Tyrode`s solution (Gordon, Grunfeld, Garrisi, Talansky, Richards & Laufer 1988), mechanical perforation of *ZP* (Cohen et al., 1988) or complete removal of ZP. Unfortunately, these methods of fertilization led to polyspermia and increased the level of abnormal embryos.

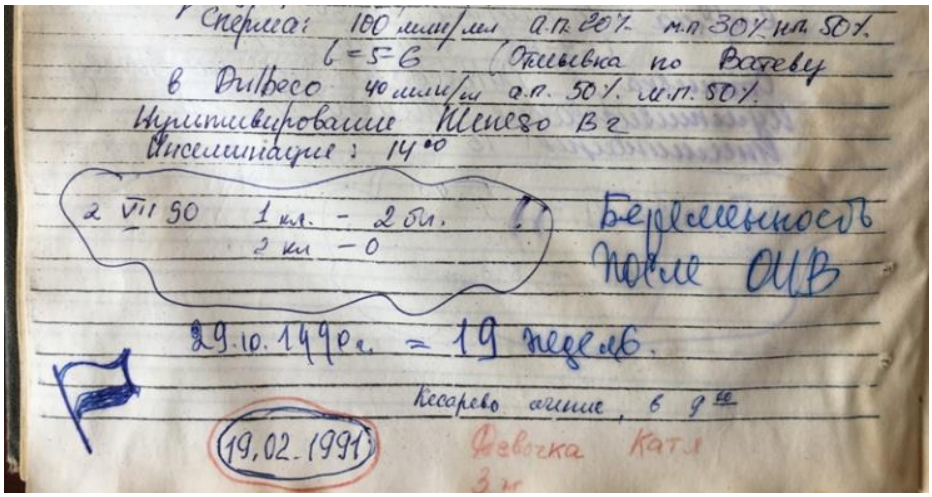

Figure 4. The note in the working journal about the first successful pregnancy in Ukraine after oocyte *in vitro* fertilization and embryo transfer into the patient's uterine cavity (Author's photo).

The method of subzonal insemination (SUZI) also allowed to bypass the *ZP* barrier (Ng et al., 1988). This procedure has been successfully developed for motile spermatozoa, however has been limited in cases of severe male infertility such as asthenozoospermia. In this situation spermatozoon, when introduced into the perivitelline space, does not fuse with the oocyte membrane and fertilization does not occur.

An important milestone in ART was the emergence of technology of intracytoplasmic sperm injection (ICSI) into the ooplasm in 1992 in Brussels (Palermo Neri, Takeuchi & Rosenwaks, 2009). This method is used for infertility treatment of couples with male infertility factor which drastically increases successful ART outcomes.

After the first report about the birth of a child using ICSI, the procedure has been steadily gaining popularity in other European countries, and then spread around the world (Palermo et al., 2017). During the 1990s, the ICSI method proved invaluable while using testicular and epididymal spermatozoa (Schoysman, 1993) in case of absence of spermatozoa in ejaculate, for the fertilization of cryopreserved oocytes (Porcu, Fabbri, Seracchioli, Ciotti, Magrini & Flamigni, 1997), and *in vitro* matured oocytes (Chung et al., 2000). Consequently, advances in reproductive medicine through the capabilities of ICSI have prompted the use of this technique not only according to indications of male infertility (O'Neill, Chow, Rosenwaks & Palermo, 2018).

Another milestone in the ART development is associated with the invention of protocols that allow preserving female and male fertility or excess amount of embryos

for subsequent transfer. A breakthrough in this area was creation of oocyte cryopreservation method by vitrification. First childbirth after using this method was reported in 1999 (Kuleshova, Gianaroli, Magli, Ferraretti, Trounson, 1999). More cryobiological approaches for long-term low temperature storage of reproductive cells and preimplantation embryos was invented after that. Most of them are dedicated to increasing survival or improving the capacity for development and further implatation (Petrushko, Yurchuk, Piniaiev & Buderatska, 2019; Yurchuk, Petrushko, Gapon, Piniaiev & Kuleshova, 2021). This includes the introduction of cytogenetic, molecular genetic and molecular cytogenetic studies to determine the aneuploidy of the chromosome set of oocytes and preimplantation embryos (Buderatska, Gontar, Ilyin, Lavrinenko, Petrushko & Yurchuk, 2020). Numerous modifications of ART methods have been made over the years, to improved culture medium for fertilization, optimized cultivation conditions, developed new protocols for cryopreservation of spermatozoa, oocytes and embryos (Petrushko, Yurchuk, & Piniaiev, 2020).

Finally, current research on the creation of an embryo from "three parents" was another unique scientific achievement (Zhang et al., 2017). This incredible invention makes it possible for couples with genetic mitochondrial DNA abnormalities to have offspring.

Of course, many ethical issues stand in the way of developing and improving ART methods. And various associations of the world scientific and public health community regulate their implementation conditions. But looking back at the history of ART development, despite the prohibitions and certain prejudices, the global goal of preserving the humanity will always stimulate the development of technologies and the receipt of new technologies in the field of human and animal reproduction. Professionals in embryology, endocrinology, gynecology, genetics, and anatomy have laid the foundations for future achievements. This is the state of the art of the ART history which we create ourselves in laboratories and clinic cabinets, and which we hope that our descendants will be proud of.

Conclusions.

Being familiar with the scientific achievements in the field of reproductive medicine allows us to conclude that the discovery of ART was not accidental. The basis of today's achievements in the field of reproductive medicine was the long-term work of specialists from different institutions in all fields of science. Brick by brick, experiment by experiment, hundreds of clinical cases, faith and great support from patients have taken the field of infertility treatment to a new level and today more than 5 million children are born who might have never seen this world, but for the scientific achievements of ART.

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Conflicts of interest.

The authors declare no conflict of interest.

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Історія допоможних репродуктивних технологій: від заборони до визнання

Анотація. *Народження дітей після лікування безпліддя сімейних пар за допомогою допоміжних репродуктивних технологій стало реальністю після багатьох років фундаментальних досліджень щодо фізіології репродуктивної системи, розробки методів запліднення in vitro ооцитів та культивування ембріонів передімплантаційних стадій розвитку. Враховуючи широке застосування допоміжних репродуктивних технологій у сучасній медичній практиці та великий інтерес суспільства до цієї проблеми метою дослідження було прослідкувати основні етапи та ключові події становлення допоміжних репродуктивних технологій в світі та в Україні, а також висвітлити діяльність видатних вчених вітчизняної та світової науки, які стояли у витоків розвитку*

цього напряму. В роботі використовувались історичні методи для вивчення та інтерпретації текстів першоджерел та представлення наукових історичних подій. Крім того, на основі результатів власного, більш ніж 30-ти річного досвіду роботи у сфері репродуктивної біології і медицини та досягнень вчених світової науки, висвітлено сучасні напрямки розвитку допоміжних репродуктивних технологій. В результаті роботи показано, що, не дивлячись на певні етичні та соціальні упередження, відкриття окремих вчених-попередників стали підґрунтя для того, щоб зусиллями Роберта Едвардса та Патрика Стептоу народилася перша в світі дитина, зачаття якої відбулося поза організмом матері. Також представлено історичні факти та унікальні фотографії з власного архіву, які підтверджують факт першого успішного запліднення ооцита in vitro та народження дитини після застосування допоміжних репродуктивних технологій в Україні. Останні 20 років допоміжних репродуктивних технологій продовжують невпинно розвиватися, вирішуючи багато інших проблем збереження репродуктивного потенціалу та лікування безпліддя. Серед сучасних методів допоміжних репродуктивних технологій можна виділити розробку способу кріоконсервування гамет та ембріонів шляхом вітрифікації, проведення генетичного скринінгу ембріонів з метою запобігання передачі спадкових хвороб, та переносу ембріонів з хромосомними аномаліями, народження дитини "від трьох батьків" при тяжких випадках мутацій мітохондріального геному та багато іншого.

Ключові слова: *репродуктивні клітини; ембріони; запліднення in vitro; перша дитина "з пробірки"; демографія; лікування безпліддя*

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История вспомогательных репродуктивных технологий: от запрета к признанию

Аннотация. *Рождения детей после лечения бесплодия семейных пар с помощью вспомогательных репродуктивных технологий стало реальностью*

после многих лет фундаментальных исследований физиологии репродуктивной системы, разработки методов оплодотворения in vitro ооцитов и культивирование эмбрионов доимплантационных стадий развития. Учитывая широкое применение вспомогательных репродуктивных технологий в современной медицинской практике и большой интерес общества к этой проблеме целью исследования было проследить основные этапы и ключевые события становления вспомогательных репродуктивных технологий в мире и в Украине, а также осветить деятельность выдающихся ученых отечественной и мировой науки, которые стояли у истоков развития этого направления. В работе использовали исторические методы для изучения и интерпретации текстов первоисточников и представления научных исторических событий. Кроме того, на основе результатов собственного, более чем 30-летнего опыта работы в сфере репродуктивной биологии и медицины и достижений ученых мировой науки, освещены современные направления развития вспомогательных репродуктивных технологий. В результате работы показано, что, несмотря на определенные этические и социальные предубеждения, открытие отдельных ученых – предшественников создали фундамент того, что усилиями Роберта Эдвардса и Патрика Стептоу родился первый в мире ребенок, зачатие которого произошло вне организма матери. Также представлены исторические факты и уникальные фотографии из собственного архива, подтверждающие факт первого успешного оплодотворения ооцита in vitro и рождения ребенка после применения вспомогательных репродуктивных технологий в Украине. Последние 20 лет вспомогательных репродуктивных технологий продолжают неустанно развиваться, решая многие проблемы сохранения репродуктивного потенциала и лечения бесплодия. Среди современных методов вспомогательных репродуктивных технологий можно выделить разработку способа криоконсервирование гамет и эмбрионов путем витрификации, проведение генетического скрининга эмбрионов с целью предотвращения передачи наследственных болезней, и переноса эмбрионов с хромосомными аномалиями, рождение ребенка “от трех родителей” при тяжелых случаях мутаций митохондриального генома и многое другое.

Ключевые слова: *репродуктивные клетки; эмбрионы; оплодотворение in vitro; первый ребенок “из пробирки”; демография; лечение бесплодия*

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The history of the world's first icebreaker “Yermak” and the significance of its first expeditions to explore the Arctic

Abstract. *In this article, the authors tried to consider and structure the stages of development and creation of the “Yermak”, the world's first Arctic icebreaker, and analyzed the stages of preparation and the results of its first expeditions to explore the Arctic. Systematic analysis of historical sources and biographical material allowed to separate and comprehensively consider the conditions and prehistory for the development and creation of “Yermak” icebreaker. Also, the authors gave an assessment to the role of Vice Admiral Stepan Osypovych Makarov in those events, and analyzed the role of Sergei Yulyevich Witte, Dmitri Ivanovich Mendeleev and Pyotr Petrovich Semenov-Tian-Shansky in the preparation and implementation of the first Arctic expeditions of the “Yermak”icebreaker. In addition, the authors considered and analyzed the assessment of Vice Admiral Stepan Osypovych Makarov and his personal contribution to the results of the first Arctic expeditions of the “Yermak”icebreaker made by Baron Ferdinand von Wrangel. The first polar*

expeditions showed that the idea of Vice Admiral Stepan Osypovych Makarov about the icebreaker fleet was viable and required further development. It is shown that the results of the first Arctic expeditions made by "Yermak" allowed to significantly develop knowledge in various scientific fields of Arctic and Earth research, namely, topography, astronomy, meteorology, hydrology, geology, magnetism, zoology, and botany. The use of these methods and approaches to scientific research allowed to retrace the way of life and professional activity of Vice Admiral Stepan Osypovych Makarov's systematically and critically evaluate the sources used, highlight the main points in the current state of studying the subject and the results of predecessors, specify the most promising directions of research, give a description of the previous works on this issue and clearly distinguish issues that have not yet been resolved.

Keywords: *"Yermak"icebreaker; Northern Sea Route; Imperial Russian Geographical Society; Vice Admiral Makarov; Arctic research; polar expeditions*

Introduction.

The name of Stepan Osypovych Makarov is inextricably linked with the idea of conquering the polar ice with the help of an icebreaker. He wanted to free the shores of Siberia from the ice and provide access to its powerful rivers, connecting these rich territories with the rest of the world via a cheap sea route. Vice Admiral Stepan Osypovych Makarov was an outstanding man of his time. He was able to brilliantly combine naval service and research, addressing the issues of both oceanology and oceanography. His oceanographic research is all the more significant because it was carried out in his spare time. Being a hard-working, ambitious, active, extremely dedicated and strong-willed, perseverant and fearless person, Stepan Makarov succeeded in many ways. One of successes, and perhaps one of the most significant, was the creation of the "Yermak" icebreaker and its first expeditions (Figure 1).

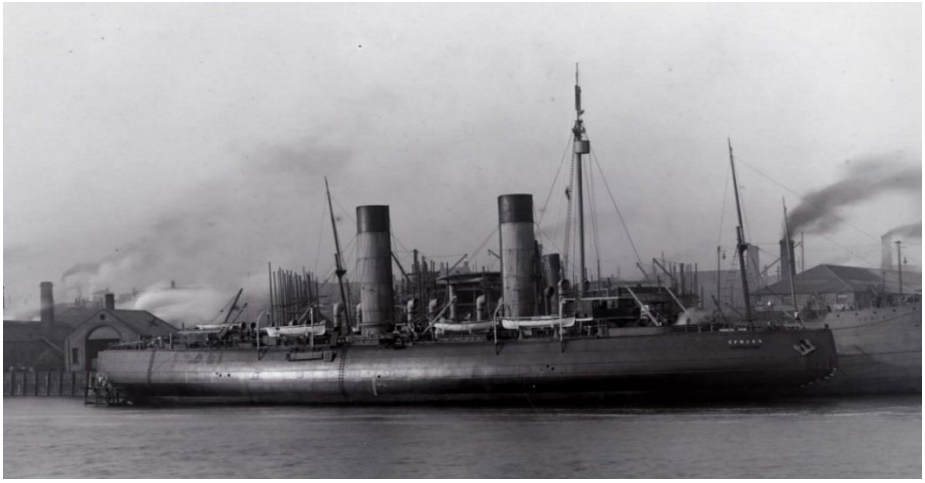

Figure 1. The "Yermak" at the in 1898 at the shipyard of Armstrong Whitworth & Co. at Low Walker on the Tyne (Tyne & Wear Archives & Museums, 2013, November 27).

The "Yermak" icebreaker brought Makarov worldwide recognition and fame and made him a national hero (Wrangel, 1913, p. 221). However, there are few scientific researches dedicated to the very idea of using icebreakers for the exploration of the Arctic, the creation of the "Yermak", its tests and scientific achievements of the first expeditions (Avkhadeev, 2018; Fyfe, 1900; Gogorev & Samsonov, 2016; Gulston, 1901; Saunders, 2017; Sukhova & Skrydlov, 2018, Czernyadjeva, Afonina, & Kholod, 2020; Ruksha, 2000; Skrydlov, 2019). Many of them briefly mention the "Yermak" icebreaker as the first icebreaker of the Arctic class, give its technical characteristics, or mention the contribution of the first expeditions in the development of the Northern Sea Route. The authors of this work haven't found any fundamental study that would either consider or structure the stages of development and creation of the "Yermak", the world's first Arctic icebreaker, or analyze the stages of preparation and results of its first expeditions to explore the Arctic. Therefore, this is the purpose and the main objective of this study.

Research methods.

Systematic analysis of historical sources and biographical material allowed to separate and comprehensively consider the conditions and prehistory for the development and creation of "Yermak" icebreaker. Also, the authors gave an assessment to the role of Vice Admiral Stepan Osypovych Makarov in those events, and analyzed the role of Sergei Yulyevich Witte, Dmitri Ivanovich Mendeleev and Pyotr Petrovich Semenov-Tian-Shansky in the preparation and implementation of the first Arctic expeditions of the "Yermak" icebreaker. In addition, the authors considered and analyzed the assessment of Vice Admiral Stepan Osypovych Makarov and his personal contribution to the results of the first Arctic expeditions of the "Yermak" icebreaker made by Baron Ferdinand von Wrangel. The first polar expeditions showed that the idea of Vice Admiral Stepan Osypovych Makarov about the icebreaker fleet was viable and required further development. It is shown that the results of the first Arctic expeditions made by "Yermak" allowed to significantly develop knowledge in various scientific fields of Arctic and Earth research, namely, topography, astronomy, meteorology, hydrology, geology, magnetism, zoology, and botany. During the preparation of the article, chronological, comparative methods of historical knowledge, classification, and systematization of historical sources and bibliographic material were used (Gaidai & Srogosz, 2021; Gutnyk, Tverytnykova, & Sklyar, 2019; Strelko, 2021; Strelko et al., 2021; Strelko & Pylypchuk, 2021). The use of these methods and approaches to scientific research allowed to retrace the way of life and professional activity of Vice Admiral Stepan Osypovych Makarov's systematically and critically evaluate the sources used, highlight the main points in the current state of studying the subject and the results of predecessors, specify the most promising directions of research, give a description of the previous works on this issue and clearly distinguish issues that have not yet been resolved.

Results and discussion.

The name of Stepan Osypovych Makarov is inextricably linked with the idea of conquering the polar ice with the help of an icebreaker. He wanted to free the shores of Siberia from the ice and provide access to its powerful rivers, connecting these rich territories with the rest of the world via a cheap sea route. Vice Admiral Stepan Osypovych Makarov was an outstanding man of his time. He was able to brilliantly combine naval service and research, addressing the issues of both oceanology and oceanography. His oceanographic research is all the more significant because it was carried out in his spare time. Being a hard-working, ambitious, active, extremely dedicated and strong-willed, perseverant and fearless person, Stepan Makarov succeeded in many ways. One of successes, and perhaps one of the most significant, was the creation of the "Yermak" icebreaker and its first expeditions. The "Yermak" icebreaker brought Makarov worldwide recognition and fame and made him a national hero. However, there are few scientific researches dedicated to the very idea of using icebreakers for the exploration of the Arctic, the creation of the "Yermak", its tests and scientific achievements of the first expeditions. Many of them briefly mention the "Yermak" icebreaker as the first icebreaker of the Arctic class, give its technical characteristics, or mention the contribution of the first expeditions in the development of the Northern Sea Route. The authors of this work haven't found any fundamental study that would either consider or structure the stages of development and creation of the "Yermak", the world's first Arctic icebreaker, or analyze the stages of preparation and results of its first expeditions to explore the Arctic. Therefore, this is the purpose and the main objective of this study.

The idea of exploring the Arctic Ocean appeared in 1892, long before F. Nansen, a Norwegian oceanographer and traveler, was sent to the Arctic Ocean (Wrangel, 1913, p. 221). Even at that time, Makarov was convinced that the polar ice could be conquered with the help of a strong ship that could break the ice. That is why he collected information about the polar ice from time to time. It should be added that before Makarov's researches, explorers could only land in the Arctic on drifting ships that froze in the ice and were carried by ocean currents. That is why there were special rescue expeditions equipped to save those ships and scientists on board.

To convince the authorities of the need to develop icebreaking in the Russian Empire, Makarov focused on the commercial advantage. In particular, he pointed out that St. Petersburg, the principal port of the Baltic Sea, was closed for 5 months due to ice, while Arkhangelsk, the main port of the White Sea, was unreachable for 7 months, not to mention large Russian rivers by the sea which were closed for 11 or 12 months. The problem of navigation in the Arctic Ocean remained unchanged under adverse conditions. February 18, 1897 during the Imperial Russian Geographical Society Council meeting P. P. Semenov-Tian-Shansky said that Vice-Admiral S. O. Makarov "expressed to many of the Society Members his thoughts on the navigation method in the polar seas with the steam icebreakers assistance". It was

finally decided to convene an emergent the Imperial Russian Geographical Society meeting and to propose Makarov "to explain the essence more clearly" (The Imperial Russian Geographical Society Herald, 1897, February 18).

First of all, the scientist gave a lecture on this issue among specialists and researchers. The scientific community gave a cold reception to Makarov's bold proposal and did not take him seriously. Similarly, speech at the Imperial Russian Geographical Society and the St. Petersburg Academy of Sciences did not yield positive results. Both of these institutions did not accept this idea and did not support it with their authority. In particular, some renowned scientists of the Geographical Society spoke as if they themselves had visited the Arctic Ocean. They were convinced that it was impossible to break the polar ice, that ice was subject to metamorphosis because of large quantities, and therefore no machine could break it.

Such a critical attitude insulted Makarov, but still could not destroy his goal. He decided to involve the ruling strata of society, people who were fascinated by new ideas and projects. Thanks to the help of P. P. Semenov-Tian-Shansky, the Vice-Chairman of the Imperial Russian Geographical Society, on March 30, 1897, he gave a landmark public lecture at the Marble Palace of the Academy of Sciences for people who had significant social weight and influence in ruling circles. That lecture was attended by ministers, representatives of big business and even members of the Imperial family the President of St. Petersburg Academy of Sciences, Grand Duke Konstantin Konstantinovich and Grand Duke Alexander Mikhailovich, heading the Naval Ministry were present (Sukhova & Skrydlov, 2018). At the beginning of the meeting, Makarov's colleague the hydrograph F. F. Wrangel performed a report on the Russian polar research history. Then Makarov told about his observations results during the voyage "on the Arctic Sea" that summer. According to Makarov: "It isn't the question to build an icebreakers or not to do it, but it's the question to build them now or wait even longer" (The Imperial Russian Geographical Society Herald, 1897, March 30). Makarov outlined the history of the ice breaking, which originated in the Russian Empire and was widely developed in the United States, as well as already known data on the study of polar ice. The aim of his project was the scientific study of the entire Arctic Ocean and the discovery of the shortest way to the Ob and the Yenisey rivers, as well as the discovery of a way to St. Petersburg during the winter.

The ruling circles expressed their interest in this project. Emperor Nicholas II ordered Sergei Yulyevich Witte, the Minister of Finance, to get acquainted with Makarov's project. Sergei Yulyevich referred to D. I. Mendeleev, who gave a positive response. After inviting Makarov for a personal audience, Witte was able to see that he was dealing with a serious scientist, a man of broad scientific views and practical reason. Therefore, he invited him to go to the Kara Sea, to the rivers Ob and Yenisey for the necessary practical research. After arriving from the trip, Stepan Osypovych submitted his report to the Minister of Finance, which was later included in his scientific work called "Yermak in the Ice" (Makarov, 1898).

Thanks to Witte's support, Makarov began work on the first domestic icebreaker. A commission was set up to work out the technical conditions for its construction, headed by Makarov. The construction of the icebreaker was entrusted to the Armstrong plant in Britain, and was thoroughly observed by the watchful eye of Stepan Osypovych. When signing the contract with this plant, it was stated that the vessel had to be tested for unsinkability by filling it with water.

Arriving in England immediately after signing the contract, Stepan Osypovych agreed on all the designs and drawings, and consulted with the builders of icebreakers from other countries to gain knowledge and practical experience.

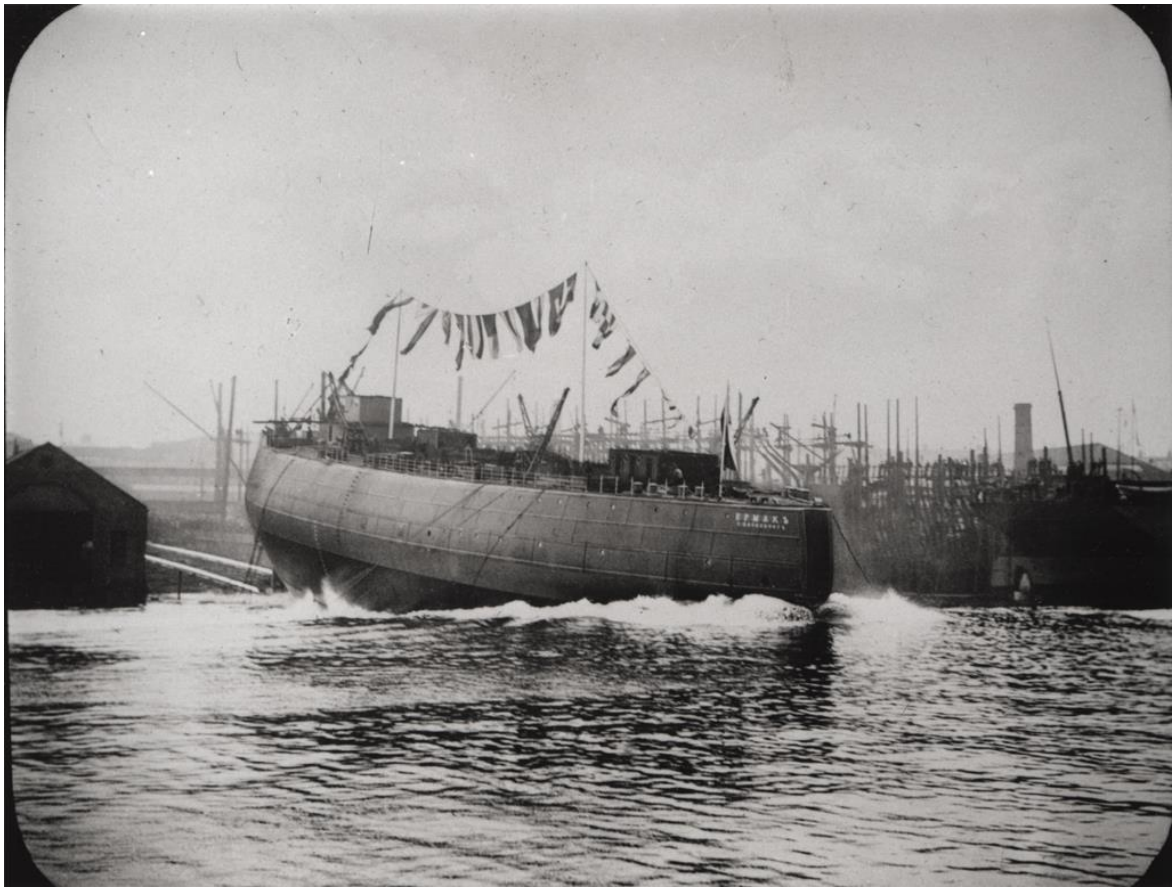

Figure 2. The launching of the "Yermak", 1898, Walker, Newcastle-on-Tyne (Lockerby, 2011).

In the summer of 1898, Vice Admiral Makarov led the Practical Squadron of the Baltic Sea, and that is why Mikhail Petrovich Vasiliev, his devoted student, a young captain of the 2nd rank and a talented sailor had to take control over the construction of the icebreaker (later he became the captain of the "Yermak", and died in 1904 on the Petropavlovsk battleship together with Makarov). Although Makarov could not visit the launch of the icebreaker on October 17, 1898, he was present at the ship's tests for unsinkability. These tests were quite successful. In general, many useful constructive improvements were applied on the "Yermak" according to Makarov's personal orders. Baron Ferdinand Ferdinandovich von Wrangel, his friend and

biographer, noted in his memoirs that after the "Yermak" was built, he met with engineers and craftsmen who built the ship. The British highly valued Vice Admiral Makarov's skills and talents, respected his knowledge of shipbuilding, and admired his ability to find a way out of any difficult situation even if experienced engineers couldn't.

The design of ships specifically intended for breaking ice is a relatively new branch in the field of naval architecture. Interest in the polar regions, as recorded by the expeditions to these areas in the early 19th century, predated by many years the development of materials and power plants required by ships to operate in these regions. The first seagoing icebreaker, "Yermak" (Figure 2), was built for the Russian government in 1898. The ship was built of steel, with l£ inch plating along the waterline. "Yermak" displaced 10,000 tons and had engines of over 10,000 HP. Her design proved successful and she is generally regarded as the prototype of seagoing icebreakers (Hill & Coburn, 1961).

The ship, some 319 feet long and 70 abeam, was very tubby in design. Six boilers fed either three shafts aft or one forward, allowing her to back and ram if needed– now standard procedure for icebreakers but novel at the time. Speaking of the bow, she had a strengthened hull of 29 mm plate steel sandwiched with oak and cork to allow her to break sea ice at over 7 feet thick. Her twin 55-foot high stacks and round sloping bow with a small stem and flare angles made her readily distinguishable and came to typify early icebreaker design. Even today, her hull form is imitated in even the most advanced polar icebreaker design (Figure 3).

The "Yermak" began its first voyage on February 21, 1898, leaving Newcastle for Kronstadt. It was at this time of year that the Baltic Fleet was cut off by ice from the whole country for 6 months. On March 4, 1898 "Yermak" approached the city of Kronstadt, accompanied by solemn applause and greetings from the icebreakers. Yermak's arrival in Kronstadt was a high day for the city. All the inhabitants of the city and its environs came out to meet the icebreaker: "*Each of those present felt proud for us, Russians, because there were people among us who were not only able to draw theoretical conclusions, but could also prove and confirm practical ideas to open new horizons"* (Wrangel, 1913, p. 247). Emperor Nicholas II telegraphed to Kronstadt: "*Congratulations on your arrival in Kronstadt at this time of year. I rejoice with you in the brilliant realization of your idea*" (Wrangel, 1913, p. 244).

While staying in the port of Kronstadt, the "Yermak" icebreaker freed 11 steamers with valuable cargoes that were in danger. The icebreaker returned to St. Petersburg with a lot of tourists on board, which evidenced the unusual and important work performed by Stepan Osypovych Makarov. After arriving in the capital, he became a national hero (Figure 4).

Makarov's next goal was a more difficult voyage on the "Yermak" icebreaker in the polar ice. The Vice Admiral prepared very carefully for this trip. From the outset, the Vice Admiral emphasized that the "Yermak" was not yet powerful enough to fight the polar ice, and that a positive outcome, namely the Kara Sea, or even access

to the Pacific Ocean, could only be achieved with two icebreakers. Makarov stressed that polar ice had a great resistance and "Yermak" might not be able to cope with it. Therefore, he chose a direction which, in case of falling into an ice trap, would let them return the same way with the drifting ice (and the currents beneath it).

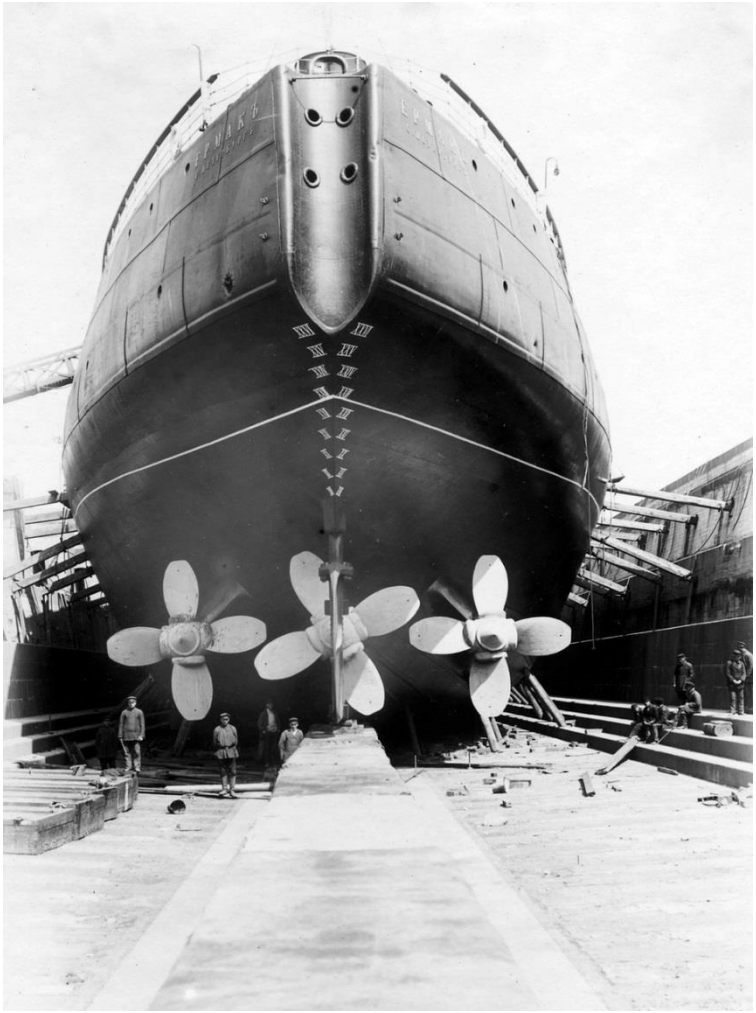

Figure 3. The icebreaker "Yermak". Note the close arrangement of her three stern screws (Eger, 2015).

In addition to engineering work and calculations, he decided to invite several scientists to the voyage in order to carry out important scientific research, especially in places where there no man has been before. For instance, the list included: Professor Fedor Fedorovich Vitram, the famous astronomer of the Pulkovo Observatory (his duties included determining the latitudes and longitudes of the signs placed at different predetermined points of the icebreaker course); Lieutenant Konstantin Fedorovich Schultz, a mine officer (he was in charge of the cinematographic and electrical parts of the work, and participated in extracting water from great depths); Baron Eduard Vasilyevich Toll, a famous scientist and traveler, was invited to study geology; Lieutenant Isaac Ibrahimovich Islamov was to perform hydrographic work; Oleksandr Hryhorovych Chernyshov, a forensic scientist, was in

charge of zoologic questions; Boris Pavlovich Ostashchenko-Kudryavtsev, Astronomer of the Pulkovo Observatory, was invited in order to make magnetic observations and study the physical properties of ice; geodetic works and research of the ice surface were carried out by cadastral engineer Konstantin Tsvetkov. In addition to scientists, Evhen Ivanovych Stolytsia, a talented artist and a student of Professor Kuindzhi, was invited to the ship. He was recommended by Count Tolstoy, Vice President of the Imperial Academy of Arts, and painted a number of beautiful still lives depicting the amazing polar nature.

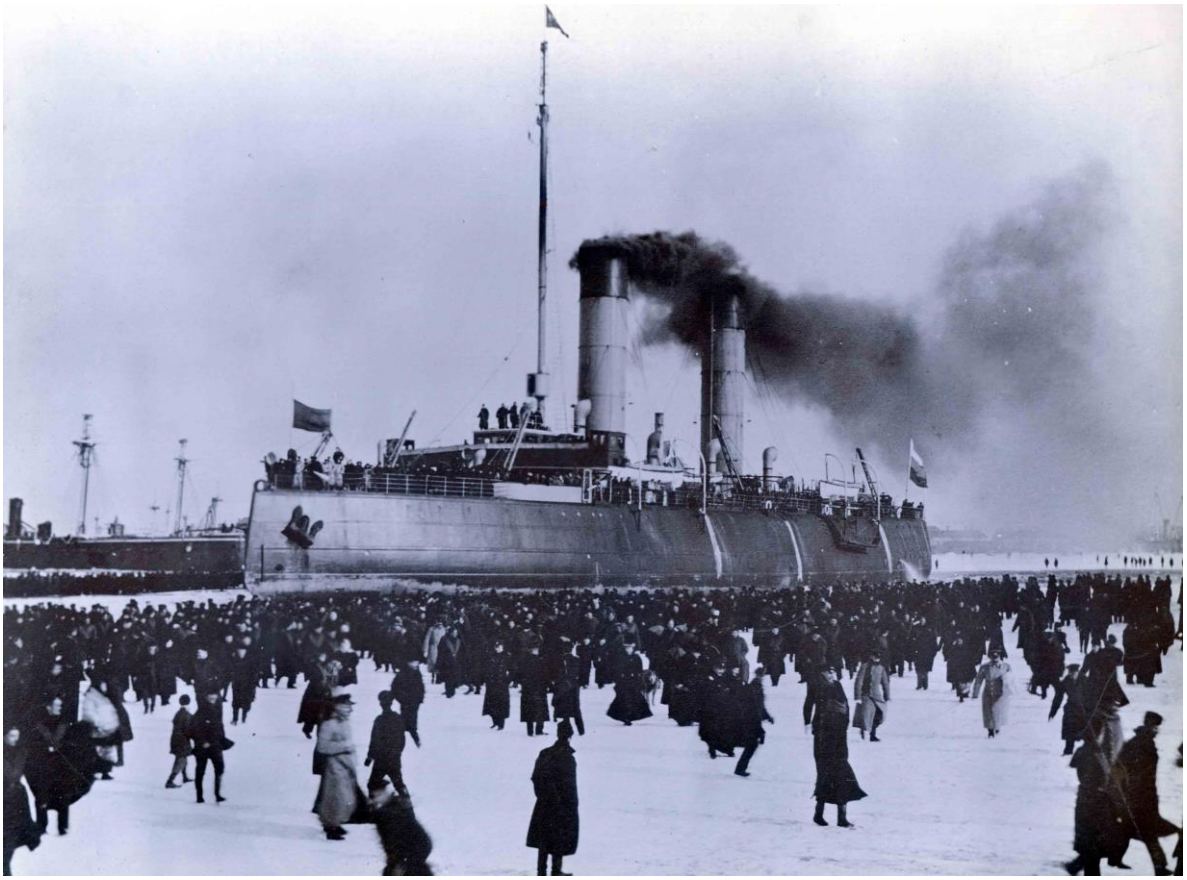

Figure 4. This photo shows the "Yermak" arriving at St Petersburg in 1899 (Tyne & Wear Archives & Museums, 2013, November 27).

In his scientific activity Makarov worked closely with the famous domestic scientist Dmitry Ivanovich Mendeleev. It was Stepan Osypovych who introduced smokeless gunpowder invented by D. I. Mendeleev to the fleet. Dmitry Ivanovich always spoke highly and positively of Stepan Osypovich, but the "Yermak" icebreaker put an end to their cooperation and friendship. Stepan Osypovych invited Mendeleev to the voyage as a researcher, but Mendeleev emphasized that the whole expedition had to take place under the auspices of his name, reducing Makarov to the position of the Head of the Naval Unit. Mendeleev wanted to lead the expedition, to determine scientific tasks, to choose the direction, and to make the final decision on every issue. In short, the famous scientist did not want to be dependent on Vice

Admiral Makarov. Shocked to the core, the Vice Admiral disagreed. Then Mendeleev called him "an upstart suffering from a mania for greatness". This is when the friendly relations of two prominent people of the late 19th century were destroyed. Of course, the voyage started without Dmitry Ivanovich.

In our opinion, this fact is very interesting, primarily because it demonstrates how general fame and recognition can affect and spoil a person's character. Mendeleev had no right to demand this, because it was well known that the "Yermak" was the brainchild of Makarov, and he himself was not only an outstanding navigator, but also a world-renowned scientist.

The first test voyage in the polar ice began on May 29, 1899, when the "Yermak" set sail from Newcastle for the Arctic Ocean. This expedition was fundamentally different from the one in Baltic Sea, because the polar ice has different properties and structure. Two weeks later, the "Yermak" returned because, according to Stepan Osypovych, the hull was not yet strong enough to travel in the polar ice. A month later, on July 14, 1898, the second test voyage of the icebreaker began. The Vice Admiral's records show that the voyage was carried out quite carefully, as there was no experience in polar voyages yet and because the ice that needed to be broken was 1.5 to 8 m thick. Throughout the voyage, the team of sailors and scientists worked harmoniously and amicably. In addition to scientific research, they even recorded a film. What's interesting, according to the Vice Admiral's records, polar bears were killed only when food was needed. In this voyage, the "Yermak" reached 81°30' to the north, quite close to the edge of the ice frame, weakened by the warm Gulf Stream.

Another interesting observation of Stepan Osypovych was that in the Baltic Sea, freshwater ice crumbled into small pieces under the icebreaker and got stuck to the ship, hindering the movement in the water. Instead, the salty polar ice broke in great chunks, making it easier to move in the water, but touching them caused shocks that were not felt in the Baltic Sea. The polar ice did not crumble, but crumpled. However, despite the caution, the "Yermak" still got a small hole at the beginning of its journey, which did not allow to dive deeper into the northern ice. It happened near Spitzbergen. In mid-August 1898, the "Yermak" returned to Newcastle. The news that the "Yermak" had returned to England due to a hole in the bow of the ship was actively used by numerous enemies and opponents of Vice Admiral Makarov. Baron F. F. Wrangel wrote: "*I was in St. Petersburg at that time, and I could not fail to mention the open malice of many people when they heard the sad news of the Yermak failure*" (Wrangel, 1913, p. 303).

The main problem was that the "Yermak" was going to fight the still unexplored northern ice and terrain. As you know, talented people always have a lot of enemies, so implementing daring ideas is always a huge risk. The conquest of the northern ice was one of them. Significant funds were spent on its implementation, but the most important was the reputation of Vice Admiral Makarov, a man who had never made a mistake and succeeded in all his endeavors.

This failure shook Stepan Osypovych's belief that man could conquer the polar ice. The enemies of the Vice Admiral started to inflate a kind of sensation from this fact. Baron F. F. Wrangel noted that the scandal would not be possible if Mendeleev had been on board. In that situation broken relationship with Mendeleev and the St. Petersburg Academy of Sciences exacerbated the complexity of the situation. But human pride and a stable system of values of Vice Admiral Makarov did not allow compromises, so he took the blow firmly with his head high.

In September 1898, a commission arrived in Newcastle to investigate the damage to the "Yermak". It consisted entirely of active opponents of Vice Admiral Makarov. Later in his letter to Baron F. F. Wrangel, he wrote that his extraordinary frankness was his biggest mistake, and that he shouldn't have telegraphed to the Minister immediately about the damage to the ship:

"*My frankness hurt me. After arriving in Newcastle, my frankness told me to send a telegram that the ship had a hole. My punishment for frankness was not long in coming, because the next day I received a telegram from S. Yu. Witte: "Please stay in Newcastle until the commission arrives". I should have sent a telegram: "The Yermak breaks the ice perfectly. I'll report personally". It would be vile, but reasonable, because with my telegram I gave my enemies a reason to arrange a commission and now the question is how I settle with it* (Wrangel, 1913, p. 318).

In any case, the only problem with this situation was that the ice turned out to be much stronger than the engineers thought. No one appreciated the significant and invaluable results that the Vice Admiral achieved during those two trips in the polar ice. They only paid attention to the failure, which, unfortunately, is always inherent in the Russian people.

Stepan Osypovych regretted that, unlike Russia, England would not look at this problem as a failure, but on the contrary would welcome the new interesting information and results. In contrast to his homeland, lectures on polar travel held in Newcastle caused great excitement and admiration. Despite the complexity of the situation, when the enemies enjoyed the failure of the Vice Admiral, in late 1898 Makarov finished the 507-page monograph "Yermak in the Ice", emphasizing that "*all polar expeditions (including Nansen's) failed to achieve their goal. But if we know anything about the Arctic Ocean, it is only due to these unsuccessful expeditions*" (Wrangel, 1913, p. 322). This fact suggests that the Vice Admiral had great strength of spirit. Under conditions when the average person step aside and reduce efficiency, he managed to put all the data in order and complete his fundamental scientific work. As if to the detriment of the authorities of the Russian Geographical Society, Makarov detailed the physical properties of polar ice and its behavior when exposed to an icebreaker. The monograph was published in 1901 in a brilliant edition by the well-known publishing house "Blockhouse and Efron", and consisted of 507 pages, 152 drawings (most of them were photographs of the best quality for that time), 5 maps of the polar seas with the routes of the "Yermak" icebreaker, and the results of hydrological observations.

This scientific work was divided into 2 parts. In the first part, the author spoke about the details of the whole expedition. Namely, he described how the idea of creating an icebreaker was born, how Makarov sought to convince the public of its necessity, the details of design and construction, a detailed description of the vessel and its testing on open water. In this part, the author also described the first attempts of the icebreaker to fight the ice of the Gulf of Finland, and the work in the Gulf of Finland to release the steamers trapped in the ice. Separate sections of the book were dedicated to the first and second test voyages in the Northern ice, all the joys and difficulties of these expeditions, the implemented scientific research, including the study of the physical properties of ice. In this section, the Vice Admiral detailed the work of the icebreaker in the Baltic Fleet campaign of 1899–1901.

The second part of this work was dedicated to reports, journals and notes on astronomy and navigation, meteorology, ice science, observations of ice strength and resistance to the motion of the "Yermak", determination of the Earth's refractive index, experiments with models, chemical analysis of water samples and magnetic observations. Moreover, the work included the results of zoological research, reviews of rock samples found in moraine remains on a floating iceberg, and chemical analysis of water samples. A separate chapter was dedicated to a journal of hydrological and meteorological observations during navigation.

Of course, the commission headed by Rear Admiral Berilyov, Makarov's sworn enemy and opponent, decided that the "Yermak" icebreaker could no longer go into the polar ice, but should work only within the Baltic Fleet. In response, Stepan Osypovych published a rebuttal, giving a detailed description of the reasons for this failure. In this struggle the victory remained with Makarov. S. Yu. Witte, the Minister of Finance, was an outstanding strategic thinker, and took more complex paths on his way to the top, just like Makarov. As a result, the final decision was to repair the "Yermak" and use it for the winter work in the Baltic Fleet. Then he planned to build a new bow until spring and send the fortified "Yermak" to the Arctic Ocean, north of Novaya Zemlya, and determine whether it is ready for sailing in the polar ice and carry merchant ships to the mouths of Siberian rivers.

Between 1898 and 1899, the "Yermak" icebreaker was active in the Gulf of Finland. That winter, there was a certain resurgence and a sense of security among the merchants in case a commercial steamer suddenly got trapped in ice. "Yermak" escorted commercial ships across the ice to Kronstadt and rescued ships captivated in ice. In particular, we should mention the situation with the Admiral Nakhimov, which could not leave the Baltic Sea in time due to early frosts and unplanned appearance of ice in the Gulf of Finland, as well as the General-Admiral Apraksin, which crashed into the Gotland island during blizzard, and was covered in ice (Figure 5). Thus, trade routes and connections in the Gulf of Finland were established and opened all year round, including with Kronstadt, Revel (Tallinn) and other trade hubs. But Stepan Osypovych himself no longer commanded the "Yermak" because at that time he led the Practical Squadron of the Baltic Sea, and in December 1899 he was appointed

Governor of Kronstadt. The ship was under the command of Mikhail Petrovich Vasiliev, a talented navigator and a close friend of Makarov.

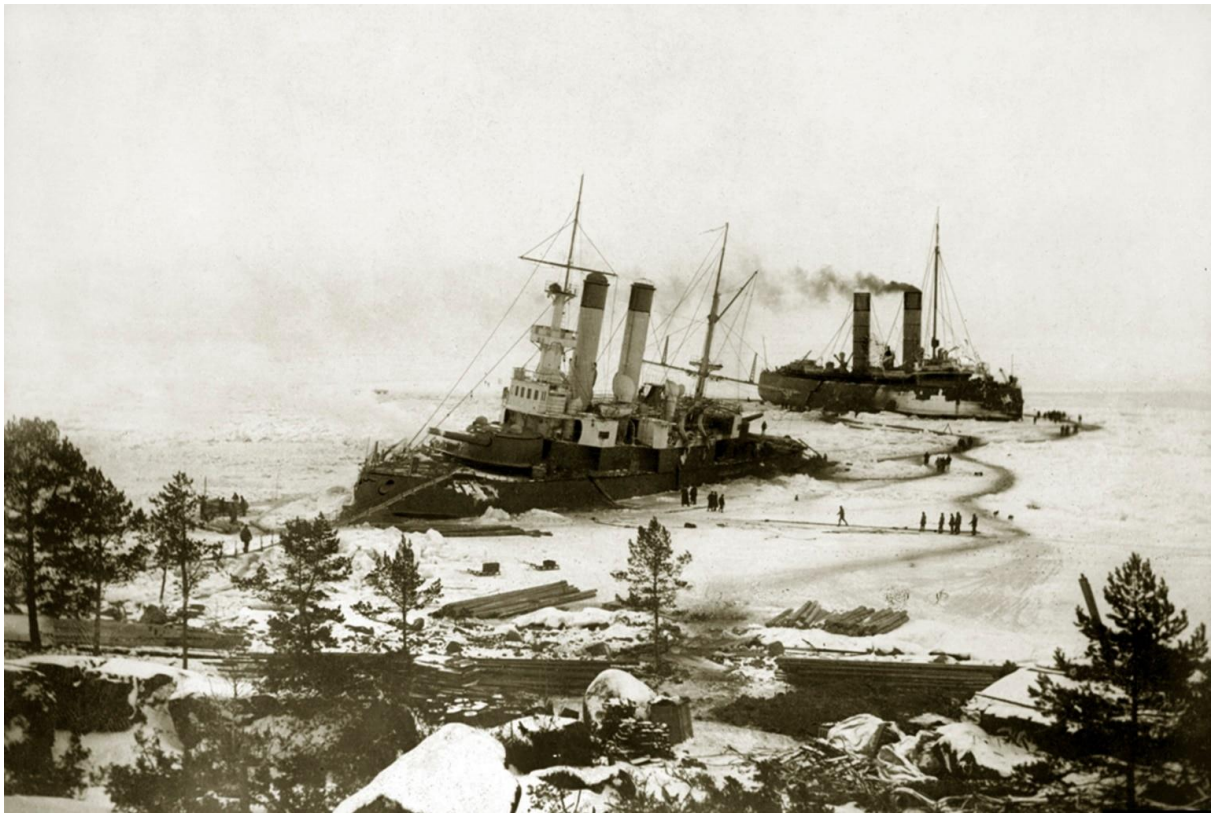

Figure 5. Icebreaker "Yermak" while rescuing the battleship "General-Admiral Apraksin" off the island of Gogland (Chapple, 2020).

In the summer of 1900, according to the contract, the "Yermak" went to Newcastle for the planned reconstruction of the bow. Even by that time, the icebreaker had brought a lot of benefits to the Russian Empire and had fully recouped the cost of construction. People say there is a blessing in disguise, so the first failure only prompted Stepan Osypovych to work harder, leading him to the long-awaited victory. This trend can be observed throughout the life and work of the prominent Vice Admiral. It is worth mentioning his fascination with mines, torpedoes and destroyers during the Turkish War of 1877–1878.

In March 1901, Vice Admiral Makarov again raised the question about the next voyage to the Arctic Ocean and addressed the Minister of Finance S. Yu. Witte. This time Makarov set a goal to get as close to the North Pole as possible. S. Yu. Witte sent Makarov's statement to P. P. Semenov-Tian-Shansky, the Vice-Chairman of the Imperial Russian Geographical Society, and to Admiral M. M. Chikhachov.

That time P. P. Semenov-Tian-Shansky did not support Makarov's idea (Sukhova & Skrydlov, 2018). In 1901, in a letter to S. Yu. Witte, after the polar research importance discussing, P. P. Semenov firmly stated that the "Yermak" didn't suit for the polar voyages and, consequently, for polar studies (Wrangel, 1913,

p. 362–365). He might have been frightened by the public response to the Yermak's first failure, or might have changed his mind. In any case, he gave a respectful but negative response to Makarov's statement. A similar conclusion can be drawn from the response of Admiral M. M. Chikhachev, who also substantiated his thoughts on the inexpediency of the voyage. They did not doubt that the icebreaker could break the ice, but they were worried about whether the "Yermak" would be able to cope with this task. Based on these reviews, Witte withheld the "Yermak" from swimming again in the polar ice. This refusal was a severe blow to Makarov, so he wrote Witte a personal letter full of hope. After that, Witte approved the voyage.

The voyage was scheduled for the summer of 1901. The main purpose of the voyage was to study and describe the route to the Ob and the Yenisey rivers through the northern part of the Novaya Zemlya and the Kara Sea in order to determine the possibility of summer sailing to the mouths of these Siberian rivers. For the Russian Empire, establishing such a trade route was very important, because it could lead to proper shipping along the entire length of these rivers. That could have a huge impact on the development of northern Siberia with its forests, minerals and fish, and would allow transporting a huge amount of agricultural and livestock products of the temperate zone (products that could not be transported by rail). Before the expedition, Stepan Osypovych emphasized that on the basis of his knowledge about the Kara Sea and the northern ice, a powerful icebreaker could pave the way for commercial steamers in the summer, but he did not consider the "Yermak" powerful enough to do this.

That time he invited many scientists to join the expedition: Baron Volodymyr Yevhenovych Gravenitz, astronomer and fleet Lieutenant; Volodymyr Kostiantynovych Neupokoiev, meteorologist and hydrologist, fleet Lieutenant; Semen Petrovych Vulkov, physicist and magnetologist, chemist of the laboratory of the Maritime Department; Valerian Mykolaiovych Weber, geologist and mining engineer; Oleksandr Hryhorovych Chernyshov, zoologist and sea doctor; Ivan Volodymyrovych Palibin, botanist and conservator at the St. Petersburg Botanical Garden; Apollon Pavlovych Ravinskyi, topographer; and Anatolii Oleksandrovych Palibin, navigator and photographer.

The "Yermak" began its second voyage in May 1901. First the expedition reached Spitzbergen. 60 miles (96km) away from Novaya Zemlya they hit the ice which was 23 feet (7 m) thick, so for several days they hardly moved at all. During the stop, scientists arranged tours to collect research material and samples or study ice and flora. The "Yermak" was captivated by the northern ice for almost a month, from June 25 to July 24, 1901. After the icebreaker was set free, Makarov decided to go to Franz Joseph Land (in particular, to Cape Flora), then to Novaya Zemlya (to Cape Ledyanoy), and then to Spitzbergen, conducting scientific research along the way. The team of scientists landed at Hochstetter Island to get acquainted with its nature and collect samples from the island which was unknown until then. It was the first time Makarov found warm water between Franz Joseph Land and Novaya Zemlya. Passing near Novaya Zemlya, they visited Cape Nassau, Pankratiev Islands,

Krestovaya Guba, Mashigina Bay, Cape Shantz, the Admiralty Peninsula, Cape Borisov and Sukhoy Nos. After carrying out the necessary scientific research, on September 1, 1901, the "Yermak" icebreaker returned to Kronstadt.

Of course, the goal of the voyage was not achieved, because the "Yermak" was not strong enough to break thick ice. However, that expedition showed that Makarov's idea on the icebreaker fleet was viable and required further development.

Returning from the expedition, the scientific team of the "Yermak" presented valuable research material. In particular, it included:

1. *Topographic data*. O. P. Ravinskyi, topographer, took photographs and held a coastal cypregel survey, which served as a basis for the map of the northern part of Novaya Zemlya, between Mashigina Bay and the northern part of the Krestovyi Gulf up to Sukhoy Nos. He also drew 4 maps of glaciers and ice fields.

2. *Astronomical data*. Gravenitz, astronomer, and Neupokoev, meteorologist, calculated the astronomical position of Cape Shantz and Cape Smirnov in the northern part of Novaya Zemlya, as determined by the noon heights of the sun and the North Star.

3. *Meteorological data*. Lieutenant Neupokoiev monitored all elements of the atmosphere every 4 hours.

4. *Hydrological data*. Data were collected continuously every 50 miles. A total of 107 hydrological stations were investigated.

5. *Geological data*. Weber, mining engineer, collected samples of marine soils on the landslides encountered at sea, and also conducted coastal studies of the structure of the earth's surface and the nature of the fossil animals. Professor Stukeberg studied corals from the deposits of Novaya Zemlya.

6. Data on terrestrial magnetism collected by S. P. Vulkov in various places on land and sea.

7. *Zoological data*. Obtained during hydrological stations, mainly from the bottom of the Barents Sea.

8. *Botanical data*. I. V. Palibin obtained important results in the study of marine phytoplankton, diatoms in the polar ice and terrestrial vegetation of Spitzbergen, Franz Josef Land, and the northern part of Novaya Zemlya in terms of its state and history of development (Gogorev & Samsonov, 2016). The beginning of bryophyte exploration can be attributed to L. V. Palibin, who participated the expedition on the icebreaker "Yermak" to the Barents Sea in 1901 (Czernyadjeva, Afonina, & Kholod, 2020). He published records of 12 moss species, collected mainly at the Flora Cape, Northbrook Island, and also small collections in Hochstetter Island (Palibin, 1903–1906) (Palibin, 1903a, 1903b, 1903c, 1903d, 1904, 1906a, 1906b). A .A. Yelenkin and V. P. Savichev were responsible for the treatment of lichens, while the rest of the spore plants (mosses, fungi, algae) brought from the expedition were studied by: Professor Broterus, Kolkwitz, Gran, Nadson, Yachevsky.

9. *Soil data*. The materials collected from this area were transferred to the Dokuchaev Soil Committee and processed by Armakovskaya.

Despite the fact that at first glance the voyage had a negative result, the expedition members held a completely different opinion. After all, they were all recognized scientists who voluntarily agreed to withstand the difficult conditions in order to replenish knowledge and information for the development of the above branches of science.

Nonetheless, they thought differently in St. Petersburg. People who had nothing to do with science saw only practical meaning and economic results of the voyage. Admiral A. A. Berilyov, the enemy of S. O. Makarov, took advantage of the so-called failure and sent a scathing letter to S. Yu. Witte: "*The "Yermak" returned with nothing: the ice remained impassable, and the ship itself was unworthy, both in design and execution, to make polar voyages and open the pole*" (Wrangel, 1913, p. 402).

No matter how hard Admiral Berilyov tried to denigrate the name of S. O. Makarov, the Yermak's second voyage was accepted even more positively than the first one. It was finally decided that the "Yermak" would no longer sail in the polar part of the ocean, and would remain in the Baltic Fleet. The "Yermak" was placed at the disposal of the Port Affairs Committee. This is how they took away Makarov's creation, to which he devoted so much work, attention and energy.

Until the very last moment, not obeying public opinion, Stepan Osypovych argued that, if the "Yermak" had not been limited in time, it would have been possible to cross the Arctic Ocean. When it was decided to equip the expedition to help Baron Tol and his comrades, S. O. Makarov suggested to use the "Yermak", but the academic commission instructed to consider this proposal rejected his opinion.

At that time Vice Admiral's contemporaries, both his friends and enemies, wondered whether Makarov's idea of icebreakers was too self-assured. Everyone had a different opinion. At that time, there was no definitive answer to this question. Here is how Baron F. F. Wrangel wrote about this:

"*There are people who only value tangible material benefit; some place the glory of the Motherland above all, others view the search of truth, the victory of man over the forces of nature as the highest task of mankind. It seems to me that in the nearest future, a renewed Russia will deploy the inexhaustible forces of its people, use the immense treasures of its natural resources, and this is when the bold opinion of the Russian hero Makarov will be realized. We will build icebreakers that will pass through the ice of the Arctic Ocean as freely as the "Yermak" passes through the waters of the Gulf of Finland. The Arctic Ocean will be studied thoroughly by Russian sailors, on Russian icebreakers, for the benefit of science and for the glory of Russia. No one can predict the economic benefits that Russia will eventually receive from this human victory over the forces of nature. But the history of mankind proves that any enrichment of science pays off a hundredfold, not to mention the moral significance of the people's readiness and ability of their sons to give themselves to misery and danger in the name of the idea*" (Wrangel, 1913, p. 404-405).

As time has shown, Makarov's voyage in the Arctic Ocean began a fundamentally new stage of Arctic conquest and exploration, as he carried it out on

the world's first powerful icebreaker. In other words, the "Yermak" icebreaker created by Makarov made two expeditions to the Arctic in 1899 and 1901. But Vice Admiral Makarov's contemporaries did not realize that is was a fundamentally new stage of the conquest of the Arctic.

In 1904, reporting to the Imperial Russian Geographical Society on the tragic Makarov's death during the Russian-Japanese War, the Chairman of the Department of Physical Geography, geologist F. N. Chernyshev noted that the "Yermak" creation "at first seemed to be a paradox" and after the first not quite successful navigation experience provoked "criticism of the very icebreaker idea" but finally turned out to be a world discovery (Sukhova & Skrydlov, 2018). Chernyshev, having himself participate in the 1901 expedition to Novaya Zemlya, organized by Makarov, believed that the "Yermak" was the most suitable vessel for fighting polar ice. Maritime department only after the Makarov's death realized the importance of using icebreakers fo the Northern Sea Route development.

The most interesting thing in this whole story is that the North Pole was reached only 5 years after the death of Stepan Osypovych, on April 6, 1909 by the American discoverer Robert Perry. It happened as predicted by Baron F. F. Wrangel: in the 20th century, researchers have advanced thousands of miles in the study of the Arctic Ocean, making a huge contribution to the development of the Arctic. There are no more white spots on the map, and all the physical, geographical, zoological and chemical properties of this ocean have been studied.

The most important thing is that the largest ridges and plateaus of this area are named after famous domestic scientists: Lomonosov ridge, Gakkel ridge, Mendeleev ridge, Makarov plateau. Despite Makarov and Mendeleev had an argument and did not find common ground in the study of the Arctic Ocean, their names will always stay next to each other, both on the map and on the ground.

Conclusions.

The Arctic voyage of the "Yermak" icebreaker leaded by Admiral S. O. Makarov has initiated a fundamentally new stage in the conquest and exploration of the Arctic.

The results of the first Arctic expeditions of the "Yermak" icebreaker allowed to significantly develop knowledge in various scientific fields of Arctic and Earth research, namely, topography; astronomy; meteorology; hydrology; geology; magnetism; zoology; botany.

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Створення першого в світі криголаму арктичного класу “Єрмак” та аналіз значення результатів його перших експедицій для дослідження Арктики

Анотація. *У даній статті, авторами вирішено завдання розгляду та періодизації етапів розробки та створення першого в світі криголаму арктичного класу “Єрмак”, а також аналізу етапів підготовки та результатів його перших експедицій у дослідженнях Арктики. Системний аналіз історичних джерел та біографічних матеріалів дозволив відокремити та всебічно розглянути умови та передісторію подій, що передували розробці та створенню криголаму “Єрмак”. Дана оцінка ролі віце-адмірала Степана Осиповича Макарова у цих подіях. Проаналізовано участь Сергія Юлійовича*

Вітте, Дмитра Івановича Менделєєва, Петра Петровича Семенова-Тянь-Шанського у підготовці та реалізації перших арктичних експедицій криголаму "Єрмак". Розглянуто та проаналізовано оцінку барона Фердинанда Фердинандовича Врангеля, щодо особистого внеску віце-адмірала Степана Осиповича Макарова та результатів перших арктичних експедицій криголаму "Єрмак" під його командуванням. Перші полярні експедиції показали, що ідея віце-адмірала Степана Осиповича Макарова про криголамний флот є життєздатною і вимагала подальшого розвитку. Показано, що результати перших арктичних експедицій "Єрмак" дозволили значно розвинути знання у різних наукових галузях дослідження Арктики та Землі: топографії; астрономії; метеорології; гідрології; геології; магнетизму; зоології; ботаніці. Під час підготовки статті використано хронологічний, порівняльний прийом історичних знань, класифікацію, систематизацію історичних джерел та бібліографічного матеріалу. Використання цих методів і підходів до наукового дослідження дозволило відстежити життєвий шлях і професійну діяльність віце-адмірала Степана Осиповича Макарова, систематично та критично оцінити використані джерела, виділити основні моменти сучасного стану вивчення предмета та результати дослідження. попередників, конкретизувати найбільш перспективні напрямки досліджень, надати характеристику попередніх робіт з цього питання та чітко відокремити питання, які ще не були до цього часу вирішені.

***Ключові слова**: криголам "Єрмак"; Північний морський шлях; Імператорське Російське географічне товариство; віце-адмірал Макаров; дослідження Арктики; полярні експедиції*

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Создание первого в мире ледокола арктического класса "Ермак" и анализ результатов его первых экспедиций для исследования Арктики

***Аннотация.** В данной статье авторами решены задачи рассмотрения и периодизации этапов разработки и создания первого в мире ледокола арктического класса "Ермак", а также анализа этапов подготовки и результатов его первых экспедиций в исследование Арктики. Системный*

анализ исторических источников и биографических материалов позволил отделить и всесторонне рассмотреть условия и предысторию событий, предшествовавших разработке и созданию ледокола "Ермак". Дана оценка роли вице-адмирала Степана Осиповича Макарова в этих событиях. Проанализировано участие Сергея Юльевича Витте, Дмитрия Ивановича Менделеева, Петра Петровича Семенова-Тянь-Шанского в подготовке и реализации первых арктических экспедиций ледокола "Ермак". Рассмотрена и проанализирована оценка барона Фердинанда Фердинандовича Врангеля, относительно личного вклада вице-адмирала Степана Осиповича Макарова и результатов первых арктических экспедиций ледокола "Ермак" под его командованием. Первые полярные экспедиции показали, что идея вице-адмирала Степана Осиповича Макарова о ледоколомном флоте является жизнеспособной и требовала дальнейшего развития. Показано, что результаты первых арктических экспедиций "Ермака" позволили значительно развить знания в различных научных областях исследования Арктики и Земли: топографии; астрономии; метеорологии; гидрологии; геологии; магнетизма; зоологии; ботанике. При подготовке статьи использовались хронологический, сравнительный методы исторического познания, классификации и систематизации исторических источников и библиографического материала. Использование данных методов и подходов к научным исследованиям позволило проследить жизненный путь и профессиональную деятельность вице-адмирала Степана Осиповича Макарова, систематически и критически оценить использованные источники, выделить основные моменты современного состояния изучения предмета и результаты исследования предшественников, конкретизировать наиболее перспективные направления исследований, дать описание предыдущих работ по данному вопросу и четко выделить вопросы, которые еще не были до этого времени решены.

Ключевые слова: *ледокол "Ермак"; Северный морской путь; Императорское Русское географическое общество; вице-адмирал Макаров; исследования Арктики; полярные экспедиции*

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Historical aspects of construction and operation of train ferry routes

Abstract. *Sustainable development of the transport industry can be provided through the introduction of combined transport systems. And one of the most promising ones is the train ferry transport system which combines railway and marine transport facilities. The article deals with the analysis and systematization of the data on the historical development of train ferry routes and describes the background for the construction of train ferry routes and their advantages over other combined transport types. It also deals with the basic features of the train ferries operating on the main international train ferry routes. The study is concerned with both sea routes and routes across rivers and lakes. The article shows the role of train ferry routes in the improvement of a national economy, and in the provision of the military defense, as it was described by Vinogradov at the example of Saratovskaya Pereprava (route) and by Karakashly and Shklyaruk at the example of the lighter Ishimbay which was loaded from the side. The authors have analyzed the development of the train ferry routes serviced by the ice-breaking train ferries Baikal across Lake Baikal, and the ferries Sakhalin linked mainland Russia and Sakhalin Island. The article deals with the peculiarities of transportation by trains ferries in the USA, Japan, Azerbaijan, Dagestan, Germany, Lithuania, and some other countries, and presents the analysis of the operational features of Ukrainian train*

ferries which connect Ukraine with Bulgaria, Georgia, and Turkey. Besides, the article describes some peculiarities of the loading and transportation of passenger trains by train ferries. The study deals with structural peculiarities, and processing technology used for modern train ferries operating across the Black Sea, the Caspian Sea and the Baltic Sea. The research is based on the analysis of works by Egorov (the Marine Engineering Bureau, Ukraine). The research emphasizes the importance of train ferry transportation for the sustainable development of national economies including the economy of Ukraine.

Keywords: *train ferry; combined transportation; combined transport; marine transportation; rail ferry route*

Introduction.

The rapid development of economic relations between European countries has required reforms in the transport industry. And one of the most effective solutions in this area is the formation of combined transport systems. The maritime countries are integrated into the international transportation system through their train ferry routes serviced by specially equipped vessels – train ferries – which can transfer rail cars by sea. This type of transportation has a great number of significant advantages over the other types of combined transport, among which are

– the shorter delivery way from consigner to consignee, which can reduce the relative transportation cost;

– no necessity to transship the freight;

– less damage and fewer losses of the freight; and

– faster delivery from consigner to the consignee.

The map of train ferry routes has constantly expanded. Modern train ferries with innovative structures and processing technologies have been put into operation. The higher efficiency of this combined transportation can improve the national economy of any maritime country.

The historical development of the most important train ferry routes were analyzed in studies by Sotnikov (1993, p. 84–92). However, the author focused on the geographic features of these routes. Zemlezin (1970, p. 4–12) and Shmakov (1975, p. 87–94) considered the issue of the technical adjustment of rail cars to transportation by train ferries, and described the dynamics of rail cars during marine transportation. In his work Sukolenov et al. (1989, p. 25-34) studied the processing technology for train ferries.

Tolstov studied the peculiarities of construction and operation of the train ferry route across Lake Baikal. He also analyzed the structure and processing technology of the train ferry *Baikal*. However the author did not describe the other train ferry routes across the lake (Tolstov, 2001).

The development strategy of the railway transport system in the West African Economic and Monetary Union (WAEMU) was studies on the basis of the SWOT/AHP technique by Bouraima (Bouraima, Qiu, Yusupov, & Ndjegwes, 2020).

According to the results of the research the authors suggested the strategies for the regional integration and trade which can balance the national and regional development. However they did not analyze the impact of the already existing train ferry transportation routes on the development strategy of West African countries.

The prospects of development of Silk Road were studied by Gondauri & Moistsrapishvili (2019). The authors described the background for the development of this route and its strategic significance for Georgia, Azerbaijan, Kazakhstan, and other countries. But the study only focused on one train ferry route.

Economic evaluation of train ferry transportation at the example of the Land Ferry system was conducted in the study (Merrill, Paz, Molano, Shrestha, Maheshwari, Haroon, & Hanns de la Fuente-Mella, 2016). The authors substantiated the advantages of this combined transportation over other transport facilities. It should be noted that the historical background for this route was not described in the study.

The studies (Fomin & Lovska, 2020) and (Parkhomenko, Viznyak, Skurikhin, & Eiduks, 2020) described the peculiarities of construction and operation of train ferry routes. However the studies mostly highlighted European routes and did not analyze the historical background of their construction.

The historical aspects and the development concept of train ferry routes across the Baltic Sea in the increasing regional competition were described by Mańkowska (2015). However, the author researched only transportation of passenger trains by ferries in the Baltic Sea.

The operation features of train ferry routes were presented in the study (Tanko & Burke, 2017). The authors researched the most popular international routes. However, they did not consider the background of their construction and development prospects.

The development of Swedish ferry routes was studied (Tanko, Burke, & Cheemakurthy, 2018). In their work the authors made the comparative analysis of the prospects of development and the advantages of ferry routes in Sweden and Australia. However the historical background for their construction was not presented.

The system analysis study into the development of transport-and-technological systems of train ferries was made by (Kazymyrenko, Drozd, Yeholnikov, & Morozova, 2020). In their research the authors analyzed the advantages of train ferry transportation and its development prospects. The prospects and the advantages of combined marine transportation were also described in (Bínová, Březina & Mráček, 2018) at the example of the routes linking European countries and China. However the historical aspects of the development of train ferry transportation were not given.

The analysis of the literature presented above makes it possible to conclude that nowadays it is important to analyze and systematize the data on the historical development of the main train ferry routes, as well as the development of train ferries operating on these routes.

Therefore, the purpose of the article is to describe the main tendencies of development and operation of train ferry transportation. In order to achieve the purpose the following tasks were set:

– to study the background for the development of train ferry transportation;

– to study the peculiarities of the development of train ferry transportation in the world; and

– to study the features of development of train ferry transportation in Ukraine.

Research methods.

The basic method used in the research into the historical aspects of construction and operation of train ferry transportation is the historical approach. The research includes the analysis of periodical and historical literature which covers the issues of construction, development and operational prospects of train ferry transportation.

Results and discussion.

The world first train ferry service was launched in 1851; it operated across the Firth of Forth from Granton and Burntisland (Sotnikov, 1993, p. 84).

In Germany the first train ferry service was put into operation in 1882; the 25-km route linked Stralsund and Altefähr.

In 1905 Italy started a train ferry service across the Strait of Messina. It was an 8-km route with ten ferries in operation. The distance between the ports Villa San Giovanni and Messina was covered in 40 min.

Later on, in 1961, a train ferry route across the Tyrrhenian Sea was launched; it connected mainland Europe and the Island of Sardinia (Sotnikov, 1993, p. 85).

In 1983 Italy built the double-deck ferry *Garibaldi* to link the mainland and the Island of Sardinia. Apart from rail cars it transported wheeled equipment. It also had some passenger rooms. Rail cars and wheeled equipment were rolled on through the stern doors equipped with the ramp. The ferry had two elevators that could simultaneously lift 40-ton rail cars to the upper deck or the hold in 30 seconds. The rail cars were distributed on the hold width with a special platform moving along the transverse axis of the ferry.

The ferry was also equipped with a 25-ton crane for elevating 24 containers to the upper deck. The displacement length of the ferry was 137.8 m, the breadth – 18.9 m, the draft – 5.7 m, and the capacity – 80 rail cars. The ferry speed was 20.3 knots (Sudostroenie, 1983).

In 1909 a train ferry service started between Sassnitz (Germany) and Trelleborg (Sweden). The route was serviced by the ferries *Rügen*, *Rostock*, *Trelleborg* and others (Sotnikov, 1993, p. 85).

The ferry *Rügen* was built in 1972; it could place 37 freight cars. The automobile deck accommodated 12 freight cars or 73 passenger cars. The ferry speed was 20.3 knots (Sotnikov, 1993, p. 85; Serova, 1988). The rail cars were rolled on/off

horizontally through the stern ramp. The ferry was equipped with stabilization devices against sea disturbance (Sudostroenie, 1973).

The ferry *Rostock*, built in 1977, could transport 49 freight cars located on its five tracks. The capacity of the motorcar deck was 21 vehicles. The ferry speed was 20.5 knots (Sotnikov, 1993, p. 85; Serova, 1988).

The ferry *Trelleborg* was put into operation in 1982 and it had five tracks for rail cars. The full ferry length was 170.1 m and the breadth – 22.5 m. Its speed was 19 knots. The total length of the tracks amounted to about 700 m. The ferry could accommodate 55 rail cars. It could also transport 800 passengers. The train ferry *Gotland* (Sweden) also had five rail tracks (Serova, 1988).

In 1959 the ferry *Saßnits* was built. Its length was 137.5 m, the breadth along the fender bar – 18.8 m. The four tracks on the deck of the total length 380 m could accommodate 30 freight cars. The ferry speed was 12 knots (Serova, 1988).

The ferry *Sea Wind* (former name *Saga Wind* built in 1972), re-equipped by Blohm & Voss, German shipbuilding and engineering company, was put into operation from Stockholm (Sweden) to Turku (Finland). The ferry transported rail cars located on the main deck, trucks and automobiles on the upper and boat decks; it also carried passengers. The ferry was equipped with devices for rolling on wheeled equipment. Among them were a stern hydraulic ramp and an inter-deck ramp located on the left side, which connected the upper and boat decks, and a stem gangway on the right side for light vehicles. The ferry length was 154 m, the breadth – 21m, and the draft – 5 m (Sudostroenie, 1990).

In 1920 the shipbuilding company Bell began to build special ships to transport bulky cargo, including rail cars, by sea.

Thus, the ship *Bell Vu* transported 22 cars for an electrified railway and two steel barges from England to Buenos Aires. Each wagon weighed 37 tons. In order to save space, the eight cars were located above the barges on the special wooden platforms at a height of 12 feet thoroughly adjusted for the barges, well in advance before they were loaded on the ship.

One of the ships, *Beldjan*, transported simultaneously 24 rail cars for the underground railway, 20 locomotives, 2 small river tow-boats and engine barges with a length of up to 27 m and mass of 100 tons each. The rail cars were located in two levels (behind the mid-ship superstructure). The height of this construction was the same as the height of the bridge. The upper raw of the rail cars was mounted on the special metal frame. Besides, some types of heavy freight cargo were accommodated in the hold; that managed to compensate the elevated center of gravity (Morskoj flot, 1943).

In 1923 in order to transfer the steam ships of the series E^{Sch} and E^{Schg} from Sweden and Germany to Russia across the Baltic Sea, a ferry service was launched (Lomonosov, 1923, p. 34–45).

The ferry service between Great Britain and mainland Europe has been in operation since 1924. And the first line across the strait was from Harwich (Great Britain) to Zeebrugge (Belgium). The ferry service with France has been in operation

since 1936. In 1967 the second ferry service from Harwich (Great Britain) and Dunkirk (France) was launched. It was closed due to construction of the English Channel Tunnel (Sotnikov, 1993, p. 86).

The ferry service from Hirtshals (Denmark) to Kristiansand (Norway) was launched in 1958 with the ferry *Skagen*. Its length was 80.9 m, the breadth – 13.8 m and the speed – 18 knots. The journey time was 4 hours (Vinogradov, 1960, p. 12–18). The ferry could carry 7 rail cars placed on a 69-m track, 40 automobiles, and 600 passengers.

Later on, Germany built the train-motor-passenger-electric ferry *Teodor Heus.* It was intended for service in ice conditions. The ferry had three tracks for 30 rail cars. The middle deck could accommodate 100 automobiles. The passenger capacity of the ferry was 600 passengers with their luggage. The maximum length of the ferry was 135.9 m, the breadth – 17.7 m, the hull height – 7.35 m, the draft – 4.79 m at the water displacement 6438 tons, the traffic speed – 16.6 knots (Vinogradov, 1960, p. 18–21).

The ferry service between Travemünde (Germany) and Hanko (Finland) was put into operation in 1975. A three-deck ferry intended for transportation of 65 rail cars was in the service. In 1979 the ferry length was extended, thus, its capacity was increased by 30%. And in 1984 the route was supplied with another ferry (Sotnikov, 1993, p. 86).

Ferry transportation was also introduced in America. The loaded freight cars were transported by the tugboats *Dalzell* and *Transfer* (Vinogradov, 1960, p. 21). The tugboats transferred rail cars from station to station along the river Hudson, and also to New Haven. Two ferries loaded with 20 rail cars each were simultaneously towed.

An 18-km route in the Strait of Georgia was serviced by two ferries. They transported both passengers and freight. The journey time was 55 min. One ferry was in operation between Matane and Baie-Comeau (45 km). It transported freight cars. The journey time was 2 hours (Serova, 1988).

In 1964 the longest ferry service in the Pacific Ocean region was introduced between Canada and Alaska (over 2000 km). Double-deck ferries were in service on the route.

The ports Goose Bay and Lewisport in the Atlantic Ocean were linked by a 615 km ferry service. The journey time was 30 hours. The ports Sydney and Port aux Basque were also linked by ferry service. Its length was 164 km. The journey time was 6 hours. The length of the ferry service from Cape Tormentine to Port Borden was 14 km. The ferry transported passengers and freight. The journey time was 2 hours (Serova, 1988).

Japan operated ferry service between the islands Honshu, Hokkaido, Shikoku and Kyushu. The ferry route between Hakodate (Hokkaido) and Aomori (Honshu) was 103.7 km, between Tamano (Honshu) and Takomatsu (Shikoku) was 17 km, between Niigata and Oarai was 34.8 km, and between Simonesi (Honshu) and Moji (Kyushu) was 3.4 km (Vinogradov, 1960, p. 22).

The route from Somory to Hakodate was serviced by a passenger ferry that could accommodate 1200 passengers and 19 rail cars, and a freight/passenger ferry that was intended for 300 passengers and 45 rail cars.

In 1962 the rolling stock units from Baku to the northern coast of the Caspian Sea were transported in accordance with the working project on the re-equipment of the seaborne barge *Ishimbay*. It was a dry-cargo one-deck non-self-propelled double-bottom barge intended for transportation of containers, timber, cotton and grain both in rooms and on the deck (Karakashly, Shklyaruk, 1965).

It had 16 rail tracks on the specially designed platforms for the rolling stock units. They were located on the main deck above the hatch covers across the width and were perpendicular to the centerline plane. The platform length was chosen according to the largest dimension of a rolling stock unit with consideration of rolling-on/off from the left side. The vehicles were rolled on from the head to the stern. The rail tracks of the ferry were joined to the port tracks with pads and screws. The first vehicle was rolled on the stem track with a diesel locomotive and a buffer wagon. There were two variants to fasten a rolling stock unit on the barge deck. The first one supposed the chain binders of a 17-mm chain gauge with a special spring turnbuckle damping dynamic jerks from sea disturbance. The binders were fixed with brackets to the special eye plates welded to the frames of rolling stock units, decks, and hatch covers on the barge.

The second variant provided for application of the rigid buckles made of fabricated wagon buckles intended for 30 tons. Wooden wedges were used as supports hammered between the wheel bogie and the frame.

Due to lack of time the second variant was chosen as less labor-intensive in production.

The deck of the barge *Ishimbay* turned out to be reliable and efficient for transportation.

The shipment across the Caspian Sea was conducted by the ferry *Soviet Azerbaijan* manufactured by the shipyard Krasnoye Sormovo (Figure 1).

Figure 1. Train ferry *Soviet Azerbaijan* (Forum rechnyh puteshestvennikov, 2009).

The ports Baku and Krasnovodsk (160 miles) were connected by the ferries *Soviet Azerbaijan* and *Hamid Sultanov* built from 1962 to 1968 (Kuzovkin, 1984).

The journey time was 12 hours with 3-hour stops in the destination ports (Ershov, 1978). All rail cars were located on one deck. The ferry length was 133.8 m, the width along the fender bar – 18.32 m, and the maximum draft – 4.4 m. The ferry could accommodate about 30 rail cars (Rachkov, 1960).

Later on the train ferries *Soviet Dagestan* (see Figure 2 (Nash Baku, n. d.)), *Soviet Tajikistan* (see Figure 3 (Henderson, 2020)) and *Soviet Kalmykia* were built in Yugoslavia by the shipbuilding company Uljanik for servicing the route between Baku and Krasnovodsk. The ferries had a closed rail car deck along the whole length with tracks for rail cars and the hold for the light vehicles. The rolling-on/off was conducted across the head water-proof doors. The lower deck had a ramp for rolling cars into the hold.

The ferry length was 154.4 m, the fender bar width – 18.3 m, the maximum draft – 4.5 m, and the speed – of 17 knots. The ferry could accommodate about 30 wagons (Frik, 1985).

The wagons were fastened on the decks with the chain binders through the deck eye plates and the wagon frame, and by means of the tension mechanical device Speed Lash with a link length of about 2.5 m and the operating tension 80 kN. Similar devices were used for automobiles and trailers. The automobiles were fastened with soft lashing ropes and deck eye plates with braking strength of 12 kN. The stem part of the lower deck was equipped with four end buffers with a SA-3 automatic coupler. The cars were maintained on the brake by the compressed air system connected to them (Kirsanov, 1985). The impact of the sea disturbance was moderated with the active disturbance control system equipped with the side steering wheels. The system decreased the disturbance amplitude from 19^0 to 4^0 at the speed 17 knots and sea disturbance of 7 points (Kuzovkin, 1984).

Such ferries operated on the ferry route from Baku to Aktau and were introduced in 1985 (Kargin, 1986).

Figure 2. Train ferry *Soviet Dagestan* (Nash Baku, n. d.).

Figure 3. Train ferry *Soviet Tajikistan* (Henderson, 2020).

The ferries *Soviet Kazakhstan* and *Soviet Turkmenistan* were built to link Krasnovodsk and Bekdash (Kargin, 1988). The journey time was 9 hours.

With time the number of ferries across the Caspian Sea totaled thirteen (Zorin, 1988). Among them were *Soviet Nakhchivan*, *Soviet Kirgizia*, *Soviet Uzbekistan* and others.

Besides, the ferry *Mercuri-2* operated across the Caspian Sea (see Figure 4 (Korabli vsekh vremen i narodov, 2016, January 26)). But in 2002, due to the loss of stability of the tank cars on its deck, it sank. It carried 16 tank cars with petroleum products, one car with consumer goods, 8 passengers and 42 crew members. The tank wagons fetched away from the fasteners due to the wave impact and slipped to the slope side; thus, it capsized (Kasumova, 2002).

In 2008 the train ferry *Akademik Zarifa Aliyeva* was put into operation (Figure 5 (Korabli vsekh vremen i narodov, 2017)). It was built by the shipbuilding company Uljanik (Croatia). The ferry length was 154.5 m, the breadth – 17.5 m, the capacity – 52 wagons (Korabli vsekh vremen i narodov, 2017).

Figure 4. Train ferry *Mercuri-2* (Korabli vsekh vremen i narodov, 2016, January 26).

Figure 5. Train ferry *Academic Zarifa Alieva* (Korabli vsekh vremen i narodov, 2017).

The innovative technologies of that time were used to allocate rail cars on the ferry. The ferry was equipped with special devices and elevators (Korabli vsekh vremen i narodov, 2017).

The shipbuilding company Uljanik also built the train ferries *Makhachkala-4* for operation across the Caspian Sea from Makhachkala to Aktau or Turkmenbashi (see Figure 6 (Korabli vsekh vremen i narodov, 2017)). The ferry length was 154.5 m, the breadth – 18.3 m, the draft – 4.67 m, and the capacity – 52 rail cars. The ferry speed was 14 knots (Informacionnoe agentstvo REGNUM, 2005). It could transport up to 52 rail cars (Gadzhiev, 2005).

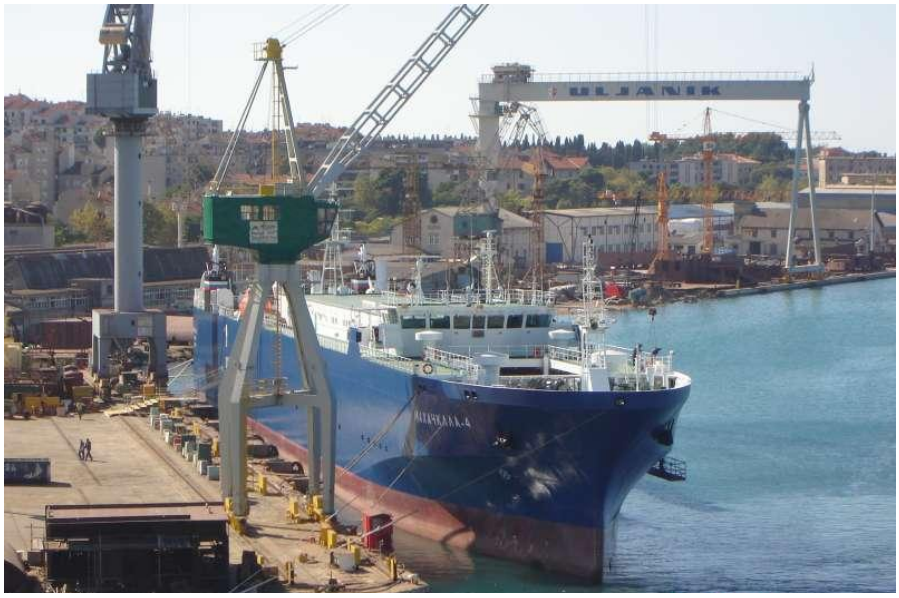

Figure 6. Train ferry *Makhachkala-4* (Korabli vsekh vremen i narodov, 2017).

The Vanino–Kholmsk train ferry service connected mainland Russia and Sakhalin Island. It was launched in 1973. The rail cars were carried by the ferry icebreaker *Sakhalin* (Figure 7 (Starinova & Shcherbakov, 2018)). The ferry length

was 127 m, the breadth – 19.8 m, the draft – 6.2 m, and the speed – 18 knots. The ferry had a rail car (main) deck with four rail tracks for rolling stock vehicles. The cars were located by batch on two middle and two side tracks.

Figure 7. Train ferry *Sakhalin* (Starinova & Shcherbakov, 2018).

The loading/unloading operations were conducted across the ramp rested on the stern step of the deck. The rail cars were loaded with locomotives on two tracks simultaneously, and automobiles were rolled on with their own power (Rachkov, Bubnov, Evstifeev, 1972). At present there exist a great number of such ferries.

Port Borden (Prince Edward Island) and Cape Tormentine (New Brunswick) in Canada were connected with an ice-breaking train ferry. The ferry length was 106 m, the breadth – 18.6 m, the draft – 5.8, and the speed – 16.5 knots. The ferry could accommodate 19 freight cars, 60 automobiles, and 900 passengers (Kilesso, 1945).

The diesel ferry *Malmohus* connected Copenhagen and Malmo. The ferry length was 94.1 m, the breadth – 16 m, the draft – 4.1 m, and the speed – 17 knots. It was intended for simultaneous transportation of 3100 passengers and freight cars (Kilesso, 1945).

Poland also began to develop ferry transportation. Thus, after WWII the train ferry service was launched between Świnoujście and Sweden with only one ferry. In 1953 the ferry service suspended for some period. And in the mid-1960s it was resumed with passenger-automobile ferries.

The ferry route from Świnoujście to Ystad was serviced by the ferries *Nikolaus Copernicus* and *Johannes Hevelius* manufactured in Norway in 1973 and 1975, respectively. The train ferries transported rail cars and trucks. They make several runs per day by necessity (Wojewódka, 1979).

In October 1986 the ferry service between Klaipeda (USSR) and Mukran (GDR) was introduced. The 540-km route was serviced by the train ferries *Klaipeda* and *Mukran* (Figure 8 (Korabli vsekh vremen i narodov, 2016, February 02)). The ferry length was 190 m and the breadth – 28 m. The ferry speed was 16 knots (Morskoj flot, 1987).

They were double-deckers and could transport 103 rail cars. For the first time, the revolutionary loading/unloading technology of that period was used for the route. With its two decks, the ferry joined a 45-m suspension double-deck ramp.

Figure 8. Train ferry *Mukran* (Korabli vsekh vremen i narodov, 2016, February 02).

The ramp was the front part of a 175-m platform. Each level had five rail tracks similar to those on the decks. Two decks cannot be loaded simultaneously as it could cause loss of stability.

The speed of the locomotive used for loading/unloading operations was 1 m/sec.

An automated anti-tilting system was used for maintaining stability within a range of 3^0 during freight operations (Shishin, 1986).

In 1989 the new Ro-Ro/Rail/Passenger ferry *Kaunas* was put into operation (Figure 9 (Informacionnoe agentstvo QIRIM HABER AJANSI, 2017)). The vessel was supervised by the Lloyd's shipping registry. The full length of the ferry was over 190 m and the breadth – 28 m. Two freight decks could simultaneously accommodate 49 universal rail cars and 50 heavyweight trucks TIR (Informacionnoe agentstvo QIRIM HABER AJANSI, 2017).

Figure 9. Train ferry *Kaunas* (Informacionnoe agentstvo QIRIM HABER AJANSI, 2017).

In 2006 the ferry service between Ust-Luga and Baltiysk was put into operation. It was serviced by the train ferry *Baltijsk* (Figure 10 (Korabli vsekh vremen i narodov, 2015). The ferry length was 187.36 m and the breadth – 22 m. The total length of the rail tracks was 1943 m. The capacity of the ferry was 135 rail cars (the length of couplers' axles was 12,020 m) or 92 rail cars (the length of couplers' axles was 16,970 m). Besides, the ferry could carry 76 automobiles on the open upper deck. The ferry speed was 18.5 knots.

The ferry had three freight decks with five rail tracks each. The loading of the middle deck was conducted through the stern doors. Rail cars and wheeled equipment were lifted up and put on the upper and bottom decks with a double-deck elevator with a freight capacity of 94 tons. The upper and lower elevator's platforms had freight areas of the length 28 m with clamping grips for the car wheels and holes to fix lashing ropes.

The cars were transferred on the decks with rotating hands installed in the stem part of the upper and bottom decks. The ferry was also equipped with seven shipboard trailers.

Figure 10. Train ferry *Baltijsk* (Korabli vsekh vremen i narodov, 2015).

The rolling-on/off of the freight in ports without dock ramps was conducted with special removable ramps mounted on the stern area with special holes for lashing ropes of hydraulic winches on the middle deck on the left and on the right. A set of removable ramps could be stored in ports or on ferries (Egorov, Kuzmin, & Ilnitskij, 2006; Kuzmin & Egorov, 2006).

Later on the ferries *Ambal* (Figure 11 (Sudostroenie.info, 2020) and *Petersburg* (Figure 12 (Novyj Kaliningrad, 2017)) were put into operation on the route.

Figure 11. Train ferry *Ambal* (Sudostroenie.info, 2020).

Figure 12. Train ferry *Peterburg* (Novyj Kaliningrad, 2017).

The ferry services from Romania to Turkey and from Romania to Georgia, which shortened the distance by 340 km and 1075 km respectively, used the three-deck ferries *Mangalia* and *Eforie* belonging to the state-owned freight railway business of Romania CFR Marfă. These ferries could carry 85 – 100 rail cars located on the deck's rail tracks with a distance of 1435 mm between the running edges of rail heads; the total length was 1680 m.

The ferries had a lift for transferring rail cars from the middle deck to the upper or bottom decks, and a deck crane of five rail tracks for fitting with the on-land rail track infrastructure. To transfer rail cars from one track to another the ferry decks were equipped with one movable platform on each deck. Besides, the ferry had a switching device for shunting operations.

The ferry service was launched across the Black Sea in the middle of the 20th century. In 1958 the European and Asian shores of Turkey across the Bosporus Strait were connected between the ports Sirkeli and Haydar (Egorov, Ilnitskij, & Chernikov, 2014).

In March 1955 the ferry service connected Ukrainian and Russian Republics of the former Soviet Union.

Two train ferry complexes between the stations Crimea and Caucasus were built to shorten a journey time of mass freight transportation between the republics. That train ferry service shortened the distance up to 1000 km, and relieved the Rostov railway junction.

Due to a short distance of about four kilometers, the ferry service across the Taman Bay was considered to be rather safe for the rolling stock units, despite the harsh climatic conditions in that region.

As far as Kerch has always been a cross-road of great merchant routes from Europe to Asia, from the Varangians to the Greeks and one of the Great Silk road, the Crimea-Caucasus train ferry service has always been an important link in the transport corridor connecting Ukraine with Russia, Kazakhstan, countries of Caucasus and Central Asia by means of the sea rail ferry routes in the Caspian Sea: from Makhachkala to Aktau and from Makhachkala to Turkmenbashi (Chikanovskij, 2004).

At first the route was serviced by four train diesel electric ferries: *Yuzhny* (Figure 13), *Eastern* (*Chulym* and *Nadym*, respectively (Proekt 723 (zheleznodorozhnye paromy, n. d.)), *Northern* and *Zapoliarny*. These ferries were intended for transportation of 16 freight cars.

Figure 13. Diesel electric train ferry *Yuzhny* (Proekt 723 (zheleznodorozhnye paromy, n. d.)).

After the collapse of the Soviet Union in 1986, the volume of transportation via the route considerably decreased and later on it was closed. It was not until October 2004 that the ferry service was resumed due to the combined efforts of Ukraine and Russia (Egorov, 2007; Sudostroenie i sudoremont, 2004).

And now the ferry service is in operation with the one-deck ferries *Petrovsk* and *Annenkov* (Figure 14) with combined capacity of 25 rail cars.

a) *b)*

Figure 14. Train ferries on the Crimea – Caucasus route
a) *Annenkov*; b) *Petrovsk* (author's photo).

The ferry decks have four rail tracks for location of rail cars. The ferry length is 110.5 m, the breadth – 16.0 m and the draft – 3.2 m. The speed of the train ferry is 10.0 knots (Nastavlenie po krepleniyu gruza, 2005).

Due to a constant increase in the freight turnover during the recent years, there has been a need to increase the throughput capacity of ferry transportation. In 2007 the one-deck ferries *SMAT* and *FERUZ* (Figure 15 (Morskoe Inzhenernoe Byuro, Proekt CNF03.01, n.d.)) with the capacity 50 tank cars 1-T with five tracks on the ferry deck were built for the ferry routes Caucasus (Russia) – Samsun (Turkey) and Caucasus (Russia) – Poti (Georgia) (Egorov, Chistjakov, & Avtutov, 2007; Efremov & Egorov, 2007).

The special feature of the train ferry is rail tracks of the narrow and broad gauges on its deck.

a) b)

Figure 15. Train ferry *SMAT*
a) loaded with open cars (Morskoe Inzhenernoe Byuro, Proekt CNF03.01, n.d.); b) loaded with tractive rolling stock vehicles (Morskoe Inzhenernoe Byuro, Proekt CNF03.01, n.d.).

The ferry length is 150.32 m, the breadth – 22 m, and the draft – 3.8 m. The ferry speed is 10.0 knots (Efremov & Egorov, 2007).

On the basis of the analysis of positive results of the existing train ferry routes and due to the strategic targets, on the 23rd April 1975 the Soviet Union and Bulgaria signed a Treaty on organization of ferry service between the ports Illichivsk and Varna to be put into operation in 1978 (Nejding & Korotkij, 1978; Jovchev, 1984).

The port infrastructure for the ferry routes was built by the construction company Chernomorhydrostroy, and the rail infrastructure facilities were built by the construction company Odessatransstroy. One of the major features of the port Illichivsk was its advantageous position on the cross-road of main transport routes between Europe and Asia, North and South, Central and Eastern Europe, industrial regions of Russia and Ukraine, and naval communications via the Mediterranean Sea to the Atlantic and Indian Oceans (Fomin, Lovska, Píštěk, & Kučera, 2019), (Fomin, Lovska, Píštěk, & Kučera, 2020).

The following international transport corridors run via the port Illichivsk:

– TRACECA (the transport Corridor Europe – Caucasus – Asia);

– Crete corridor IX; and

– Baltic – the Black Sea transport corridor.

The ferry route was serviced by four train ferries: *Geroi Shipki* and *Geroi Plevny* from the Soviet Union and *Geroi Odessy* (author's photo) and *Geroi Sevastopolia* from Bulgaria, each could accommodate up to 108 cars 1–T, 0–T and 01–T (Figure 16 (Informacionnoe agentstvo Odessa media, 2017)). These ferries had 13 tracks for rail cars (five tracks on the upper and main decks each, and three tracks on the hold deck) (Vasil'ev, 1976).

a) *b)*

Figure 16. Rail cars on the upper decks of the ferries
a) *Geroi Shipki* (author's photo); b) *Geroi Odessy* (Informacionnoe agentstvo Odessa media, 2017).

The ferry length is 184.5 m, the breadth – 26.49 m, and the draft – 6.5 m. The speed of the train ferry is 19.5 knots (Nastavlenie po krepleniju generalnyh gruzov pri morskoj perevozke dlja teplohoda "Geroi Plevny", 1997).

The ferry routes Illichivsk – Poti (opened in 1994) and Illichivsk – Batumi (opened in 1996) are serviced by the Ro-Ro/passenger ferry *Greifswald* (Figure 17) supervised by the Lloyd's shipping registry.

The ferry was built by VEB Mathias Thesen Werft in Wismar (Germany) in 1988 and it serviced the route Rostok (Germany) – Klaipeda (Lithuania).

The ferry length was 190.8 m, the breadth – 26.0 m, and the draft – 6.0 m. The speed of the train ferry was 16 knots (Cargo securing manual Transocean Line a/s ms "*Greifswald*", 2001).

a) *b)*

Figure 17. Train ferry *Greifswald*
a) side view (author's photo); b) main deck (author's photo).

In 1996 the ferry was re-equipped and a passenger complex was added. The ferry had two freight decks that could accommodate 103 rail cars, but due to the structural features of the loading complexes in Illichivsk and Poti/Batumi, only 50 cars could be placed on the main deck. Besides, it could accommodate 50 heavyweight trailers on the deck, which was an advantage regarding bimodal transport, contrailer transport and other combined transport systems.

It should be noted that potentially the ferry could accommodate 103 rail cars, but as far as they could be accommodated only on the upper deck (due to the structural peculiarities of the loading complexes in Illichivsk and Poti), only 50 cars could virtually be loaded.

Since 2001 the ferry route Illichivsk (Ukraine) – Derince (Turkey) has been in operation with the ferries *Geroi Shipki* and *Geroi Plevny*.

Since 2013 the train ferry route between Ukraine and Georgia has been serviced by the ferry *Vilnius Seaways* (Figure 18), early operated across the Baltic Sea (Informacionnoe agentstvo Odessa media, 2017). Two freight decks could

simultaneously accommodate 50 universal rail cars and 50 heavyweight trucks. The ferry had rooms for 110 and seats for 24 passengers.

The ferry had the certificate of the Guinness World Records on being the biggest world passenger/Ro-Ro/railway ferry (Mihajlova, 2013).

Figure 18. Train ferry *Vilnius Seaways* (Informacionnoe agentstvo Odessa media, 2017).

In 2009 the group of companies AnRussTrans built the train ferries *Avangard* for 45 rail cars (Figure 19 (Klimenko, 2012)) and *Slavianin* for 50 rail cars (Figure 20 (Klimenko, 2012)) with accordance to the project of the Marine Engineering Bureau.

Figure 19. Train ferry *Avangard* (Klimenko, 2012).

The train ferry *Avangard* was intended for operation on the route Caucuses (Russia) – Varna (Bulgaria) – Samsun (Turkey) – Poti (Georgia). The ferry length was 133.67 m, the breadth –22 m, and the draft – 4.8 m. The ferry speed was 12 knots.

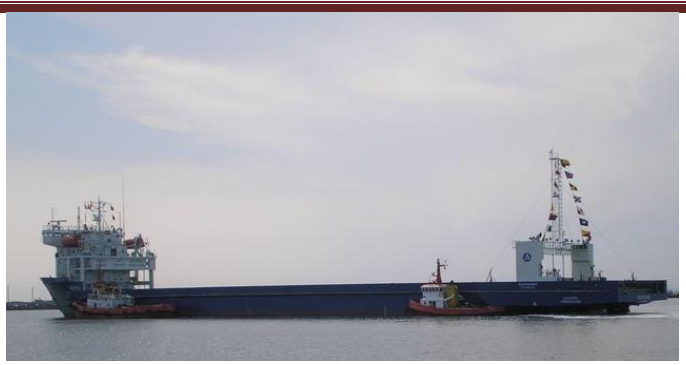

Figure 20. Train ferry *Slavianin* (Klimenko, 2012).

The train ferries were intended for operation on the route Caucuses (Russia) – Varna (Bulgaria) – Samsun (Turkey) – Poti (Georgia).

The length of the train ferry *Avangard* was 133.67 m, the breadth – 22 m, and the draft – 4.8 m. The ferry speed was 12 knots.

The length of the train ferry *Slavyanin* was 149.95, the breadth – 22 m, and the draft – 4.5 m. The ferry speed was 12 knots.

In 2010 the train ferry *Ulfat* was built (Figure 21 (Korabli vsekh vremen i narodov, 2012)). The ferry could transport 45 rail cars and was intended for the Caucuses – Varna – Samsun – Poti route. The ferry length was 133.82 m, the breadth –22 m, and the draft – 5.0 m. The speed of the train ferry was 12.0 knots (Egorov, Ilnitskij, & Chernikov, 2014).

Train ferries transported not only freight, but also passenger cars, thus they could offer seamless transportation for passengers which were accommodated in passenger rooms. And today this type of transportation is very popular. For example, the train ferries operating across the Baltic Sea can offer this service (Klochenko, 1988).

Figure 21. Train ferry *Ulfat* (Korabli vsekh vremen i narodov, 2012).

Formerly, passenger cars were placed on the deck by means of hoisting devices from the tracks of the ferry complex to the ferry's tracks. And now the cars are rolled through the ramp, which has considerably shortened the loading/unloading time.

Besides, train ferries became popular for river transportation. From 1896 to 1935 there was a ferry service across the Volga River near the town Saratov of the Ryazan-Ural Railway (Ivanchenko, & Platonov, 1943, p. 20) with the ferry *Saratovskaya Pereprava* (Figure 22 (Smorodin, 2013)). The ferry was built by the British manufacturing company Sir W. G. Armstrong Mitchel in 1896 (Volkov, 1977). The ferry had a hydraulic elevating mechanism for delivering cars from the ramp to the deck. During navigation seasons the ferry transported 160 cars per day, they were rolled on its deck. In winter seasons it transported 120 cars at shuttle service (28 cars per run).

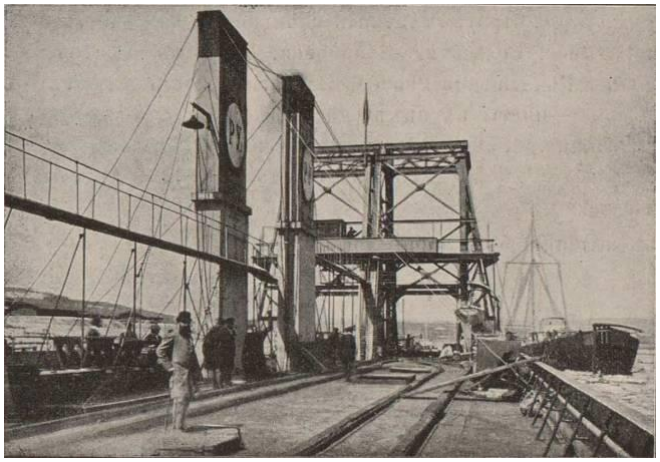

Figure 22. Train ferry *Saratovska Pereprava* (Smorodin, 2013).

Later on the ferry *Pereprava Vtoraya* (Second) built in 1909 was put into service on the route (Figure 23 (Smorodin, 2013)). It was built at the Nizhny Novgorod Machine Factory. At the most advantageous navigation period the route traffic capacity was 200 rail cars. In 1926 the ferry *Stalin* was put into operation on the route.

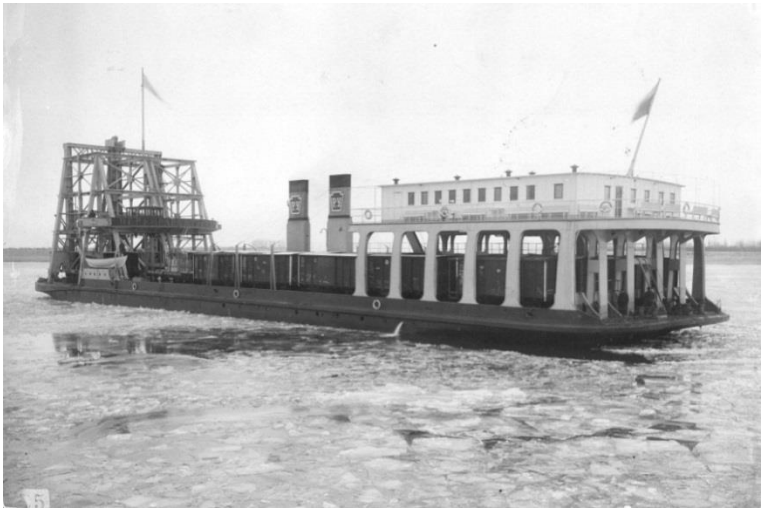

Figure 23. Train ferry *Pereprava Vtoraya* (Second) (Smorodin, 2013).

The route was also serviced by the ferry *Saratovsky Ledokol* to break ice and transport passengers and freight (Smorodin, 2013).

From 1903 to 1915 between the harbors Baikal and Tankhoy there was a ferry service across Lake Baikal on the Trans-Siberian route. The icebreaker ferry *Baikal* transported 27 rail cars. Its average speed was 18 km/h in summer and less than 11 km/h in winter. The ferry design was similar to that of the American icebreaker operating on Lake Michigan.

It was built in 1896 and had the biggest water displacement among the existing icebreakers at that time (Kilesso, 1945).

The year 1918 saw the last voyage of the icebreaker *Baikal* (Figure 24 (Shoemaker, 1903, p. 99). By its decision the Irkutsk Rada organized the Red Baikal Fleet to fight against the counter-revolutionary movement. It was damaged by field artillery fire, burnt and sank during a battle (Tolstov, 2001).

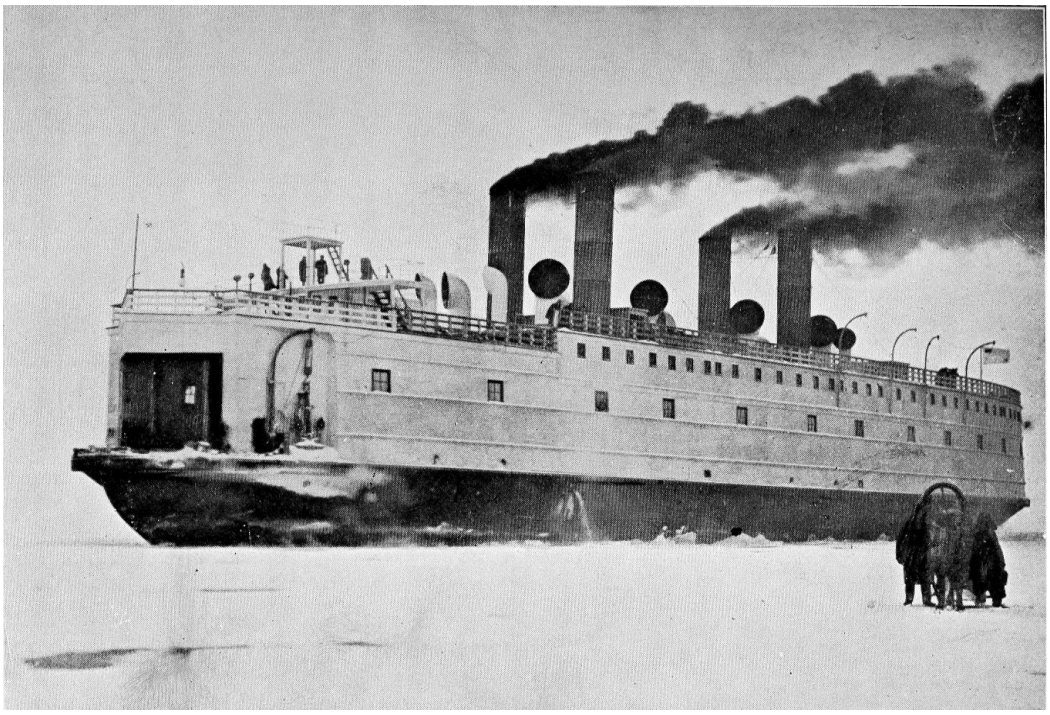

Figure 24. Icebreaker ferry *Baikal* (Shoemaker, 1903, p. 99).

In the period from 1926 to 1936 there was a ferry service between the towns Gorky and Kotelnich. The ferry had a reinforced concrete body intended for breaking ice (Volkov, 1977).

Later, on the Komsomolsk–Pivan section across the Amur River a 7-km ferry service was put into operation with the train ferries *Volga* and *Don* (both built in 1951), and *Amur* and *Komsomolsk* (both built in 1951). They were river ferries with an open deck and a wagon hoist in the head section. The wagons were located in four lines and lifted with an 80-ton device with a hoist height of up to 5 m. The wagons were transferred on the deck with trailer bogies, ropes and winch generators installed at the end of each track (Volkov, 1977).

In 1939 across the Danube River the cities Ruse and Giurgiu were connected with the ferry service for automobiles and rail cars. This route is now operable though it is not used (Telov, 2006, p. 10).

In 1941 during World War II there was a ferry route across the River Volga. A twin-hulled ferry transported rail cars. The wagons were rolled on simultaneously from two port tracks with a gradual transfer of the ferry along the dockside with two 5-ton wrenches installed in the dock at a distance of 100 m. The train ferry had 18 tracks and each could accommodate three double-axle or two four-axle rail cars, or a steam locomotive with a tender. The cars were rolled on through two suspension linkspans installed on the pier (Kupenskij, 1988).

In 1909 Norway had a train ferry across Lake Tinshe between Tinnuset and Mel. Its length was 28 km. The journey time was 1 hour 20 minutes.

Since 1964 Turkey has operated a train ferry between the ports Tatvan and Van. Its length was 90 km with two train ferries in service.

A train ferry operated between the ports Thunder Bay (Canada) and Superior (US) across Lake Superior. The route length was 285 km. The journey time was 14 hours (Serova, 1988).

There were two train ferry routes across Lake Michigan (US): Ludington – Kewaunee (105 km) and Ludington – Manitowoc (104 km). Each line operated one ferry; the journey time of each was 4 hours.

Since 1971 South American countries Peru and Bolivia have been connected with a ferry service across Lake Titicaca (Serova, 1988).

Since 1983 a ferry service has been in operation across Lake Victoria between Uganda and Tanzania in Africa. Its length was 400 km. In 1985 the line was supplied with two ferries. Their length was 92.13 m and the breadth – 16.5 m each. Each carried 22 freight cars and 5 containers. They could also carry passengers and freight.

Apart from Uganda, ferry transportation across Lake Victoria was carried by Tanzania and Kenya (Serova, 1988).

The research allowed systematizing the historical aspects regarding the construction of the biggest and most important train ferry routes. Unlike the studies by Sotnikov the authors conducted not only systematization and analysis of the geographical allocation of train ferry routes, but also investigation into the technical peculiarities of train ferries which serviced these routes (Sotnikov, 1993, p. 83-90). The authors considered both European train ferry routes and international ones (Fomin & Lovska, 2020) and (Parkhomenko, Viznyak, Skurikhin, & Eiduks, 2020), and defined the background of their construction. This was not covered in earlier publications, such as (Tanko & Burke, 2017), (Merrill, Paz, Molano, Shrestha, Maheshwari, Haroon, & Hanns de la Fuente-Mella, 2016). The authors studied both freight transportation and passenger transportation, which was not presented in the study (Mańkowska, 2015). Therefore, this research presents the analysis of the historical background and efficient operation of train ferry routes (for transportation of freight and passengers) and proves the unique nature and importance of this type

of combined transportation for development of national economies of the maritime countries.

Conclusions.

The research deals with the background for the development of train ferry transportation. It was found that train ferry transportation is advantageous over other types of combined transportation. The first successful train ferry routes encouraged engineers to develop much longer seaways, and at present, there are train ferry routes that connect countries.

The authors studied the peculiarities of the development of train ferry transportation in different countries. Successful transportation across the Baltic Sea (at the example of one of the first train ferry routes between Stralsund and Alterfähr) encouraged the specialists to develop and expand the geography of such routes to other seas: the Caspian Sea, the Black Sea, the Azov Sea, the Japan Sea, the Mediterranean Sea, and some others. Besides, such type of combined transportation was used across lakes and rivers.

The study is concerned with the development of train ferry transportation in Ukraine. It deals with the historical background for the construction of the first train ferry route, and the development of train ferry routes between Ukraine and other countries of the Black Sea. The authors analyzed the technical peculiarities of train ferries and their processing technology.

The research proves the importance of train ferry transportation for the development of national economies (including Ukraine) in the modern world.

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Conflicts of interest.

The authors declare no conflict of interest.

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Історичні аспекти створення та функціонування залізнично-поромних перевезень

Анотація. *Підвищення ефективності розвитку транспортної галузі викликає впровадження в експлуатації комбінованих систем транспорту. Однією з найбільш перспективних комбінацій в цьому напрямку виступають залізнично-поромні перевезення, які є результатом взаємодії залізничного та водного видів*

транспорту. У статті проведено аналіз та систематизацію даних щодо історичного розвитку залізнично-поромних маршрутів. Висвітлено передумови створення залізнично-поромних перевезень та їх переваги перед іншими видами комбінованого транспорту. Розглянуто основні особливості залізничних поромів, які обслуговують найвідоміші залізнично-поромні маршрути. Дослідження проведені не тільки стосовно морських акваторій, а також відносно річкових та озерних залізнично-поромних переправ. Розглянуто роль залізнично-поромних маршрутів у підвищенні економіки країн, а також їх використання у військово-стратегічних цілях, що відображено в працях Виноградова на прикладі Саратівської переправи, а також Каракашли та Шклярука – відносно ліхтера "Ішимбай" з поперечним завантаженням рухомого складу. Проаналізовано особливості розвитку залізнично-поромних маршрутів з використанням поромів-льодоколів, зокрема "Байкал", який експлуатувався через озеро "Байкал", а також типу "Сахалін", що сполучав материкову частину Росії з островом "Сахалін". Визначено особливості перевезень вагонів залізничними поромами закордоном, а саме: США, Японія, Азербайджан, Дагестан, Німеччина, Литва та ін. Проаналізовано особливості експлуатації українських залізничних поромів, які сполучають Україну з Болгарією, Грузією та Туреччиною. Висвітлено особливості завантаження та перевезень пасажирських вагонів на залізничних поромах. Визначено конструкційні особливості та технологію обробки сучасних залізничних поромів для Чорного, Каспійського та Балтійського морів. Дослідження проведені на підставі аналізу праць Єгорова Г. В. (Морське інженерне бюро, Україна). Проведені дослідження доводять важливість існування залізнично-поромних перевезень для розвитку економіки багатьох світових держав, у тому числі і України.

Ключові слова: *залізничний пором; комбіновані перевезення; комбінований транспорт; морські перевезення; залізнично-водне сполучення*

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Исторические аспекты создания и функционирования железнодорожно-паромных перевозок

Аннотация. *Повышение эффективности развития транспортной отрасли вызывает внедрение в эксплуатацию комбинированных систем*

транспорта. Одной из наиболее перспективных комбинаций в этом направлении выступают железнодорожно-паромные перевозки, которые являются результатом взаимодействия железнодорожного и водного видов транспорта. В статье проведен анализ и систематизация данных по историческому развитию железнодорожно-паромных маршрутов. Освещены предпосылки создания железнодорожно-паромных перевозок и их преимущества перед другими видами комбинированного транспорта. Рассмотрены основные особенности железнодорожных паромов, обслуживающих самые известные железнодорожно-паромные маршруты. Исследования проведены не только в отношении морских акваторий, а также относительно речных и озерных железнодорожно-паромных переправ. Рассмотрена роль железнодорожно-паромных маршрутов в повышении экономики стран, а также их использование в военно-стратегических целях, что отражено в трудах Виноградова на примере Саратовской переправы, а также Каракашлыи Шклярука– относительно лихтера "Ишимбай" с поперечным погрузкой подвижного состава. Проанализированы особенности развития железнодорожно-паромных маршрутов с использованием паромов-ледоколов, в частности "Байкал", который эксплуатировался через озеро "Байкал", а также типа "Сахалин", соединявший материковую часть России с островом "Сахалин". Определены особенности перевозок вагонов железнодорожными паромами зарубежом, а именно: США, Япония, Азербайджан, Дагестан, Германия, Литва и др. Проанализированы особенности эксплуатации украинских железнодорожных паромов, которые соединяют Украину с Болгарией, Грузией и Турцией. Освещены особенности погрузки и перевозок пассажирских вагонов на железнодорожных паромах. Определены конструкционные особенности и технология обработки современных железнодорожных паромов для Черного, Каспийского и Балтийского морей. Исследования проведены на основании анализа работ Егорова Г. В. (Морское инженерное бюро, Украина). Проведенные исследования доказывают важность существования железнодорожно-паромных перевозок для развития экономики многих мировых государств, в том числе и Украины.

Ключевые слова: *железнодорожный паром; комбинированные перевозки; комбинированный транспорт; морские перевозки; железнодорожно-водное сообщение*

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Ceramics of Halychyna in the late 19th – early 20th centuries. Scientific and professional schools. Technologies. Personalities.

Abstract. *An analysis of numerous artefacts of the first third of the 20th century suggests that the production of many varieties of art-and-industrial ceramics developed in Halychyna, in particular architectural ceramic plastics, a variety of functional ceramics, decorative tiles, ceramic tiles, facing tiles, etc. The artistic features of Halychyna art ceramics, the richness of methods for decorating and shaping it, stylistic features, as well as numerous art societies, scientific and professional associations, groups, plants and factories specializing in the production of ceramics reflect the general development of this industry in the first half of the century and represent the prerequisites the emergence of the school of professional ceramics in Halychyna at the beginning of the 20th century. The purpose of the paper is to analyze the formation and development of scientific and professional schools of art-and-industrial ceramics of Halychyna in the late 19th – early 20th centuries. The research methodology was chosen, in accordance with the specific factual material, the goals and objectives set in the work, developed on the basis of a systematic approach and the principle of historicism, using the method of complex art analysis, synthesizing the research capabilities of comparative historical, functional, typological research methods. The principle of consistency assumed the*

consideration of certain issues, in accordance with the sequence of processes that took place in such a popular variety of professional decorative applied art as art ceramics. Due to this approach, the authors tried to focus on a detailed elucidation of the ways of building professional creativity in an inextricable relationship, taking into account the characteristics of a certain material, the needs of appropriate material support, and the establishment of technological processes. Furthermore, such a presentation of the paper material has provided a clearer indication of the possibilities and prospects for the development of the artistic ceramics art. In the process of work, the authors were aware that all the problems related to the art of the first half of the 20th century, including the development in the production of art ceramics in Halychyna, are only at a certain stage of thorough study. That is why this work is one of the stages on this path. In this regard, this study was interpreted by the authors not as one that should finally exhaust the chosen topic, but on the contrary – the work should create an opportunity for further more detailed study of individual phenomena, the work of artists, or the analysis of groups of specific pieces of art.

Keywords: *decorative applied art; art-and-industrial ceramics; manufacturing technology; peculiarities; Ukrainian style; Lviv museums*

Introduction.

An analysis of numerous artefacts of the first third of the 20th century suggests that the production of many varieties of art-and-industrial ceramics developed in Halychyna, in particular architectural ceramic plastics, a variety of functional ceramics, decorative tiles, ceramic tiles, facing tiles, etc. The artistic features of Halychyna art ceramics, the richness of methods for decorating and shaping it, stylistic features, as well as numerous art societies, scientific and professional associations, groups, plants and factories specializing in the production of ceramics reflect the general development of this industry in the first half of the century and represent the prerequisites the emergence of the school of professional ceramics in Halychyna at the beginning of the 20th century.

Regarding the general dynamics of the development of art-and-industrial ceramics, it should be noted a certain peripheral weakness of economic relations in Halychyna at the beginning of the 20th century and the lack of infrastructure necessary for the development of the industry. Such conditions forced local entrepreneurs to start active activities in those industries that had deep roots in folk culture (Kara-Vasylieva, 2005, p. 257). The process of improving the art qualities of the ceramics of Halychyna of this period was slow, but progressive (Zakharchuk-Chuhai, 1979, p. 105). It was at the beginning of the 20th century that this area of decorative art was recognized as a special sphere of art activity, subject to its own laws, which had its own means of art and emotional impact. At the same time, professional artists, graduates of art schools began to work in the field of ceramic art.

In the decorative arts at the beginning of the 20th century, qualitative changes took place. This also applies to the introduction of new forms of folk culture into the

cultural-and-art space and the development of new stylistic features of decorative art. At this time, we are witnessing a process of serious interest of the creative community in folk art. An active collection and formation of museum collections, a theoretical substantiation of the very concepts of "folk art" and "decorative art" began. Consequently, an important role in the creation of individual ceramic workshops, factories, and plants, educational institutions is played by figures of Ukrainian art and science, such as Prof. Volodymyr Shukhevych, Prof. Julian Zakharievych, Prof. Ivan Levynsky, and many others.

The three named personalities were directly involved in the formation of a kind of art style that spread in Halychyna at the beginning of the 20th century. It should also be noted the support and indirect assistance to this movement of Metropolitan Andrey Sheptytsky. Moreover, such well-known figures of Ukrainian culture as I. Franko, M. Hrushevsky, K. Trylovsky, and others had a certain influence on the formation of art-and-industrial ceramics of Halychyna.

At that time, there was also an active search and development of the Ukrainian national style. The processes of shaping the latest art movements, active and fruitful cooperation of leading avant-gardists with folk craftsmen and their appeal to the symbolic language of folk art are taking place. These mutual influences lead to profound structural changes associated with the emergence of a new stylistic trend in Ukrainian modern art. The process of creating a national style was, first of all, a progressive manifestation of the patriotic feelings of the intelligentsia, the awareness of oneself as a nation.

Many researchers turned to the problems of the development of professional decorative applied art at the beginning of the 20th century and in particular – to art ceramics in Halychyna. However, only some of their works contain elements of theoretical generalization of rich factual material, as well as also cover all the traditional varieties and trends in the development of the art of ceramics. The vast majority of publications are dedicated to individual artists, art events, exhibition reviews, etc. There is also insufficient coverage of the use of expressive means taken in the visual arts – painting, sculpture, graphics – in art ceramics.

The purpose of the paper is to analyze the formation and development of scientific and professional schools of art-and-industrial ceramics of Halychyna in the late 19th – early 20th centuries.

Research methods.

The methodological basis of the work is the principles of consistency and historicism. The peculiarity of the work was to identify and to correctly understand the specifics of the period subject to thorough study. The main thing in this was the realization that the studied creative environment, as well as the creative destinies of individual artists, were subjected to an unprecedented influence of external factors, a certain ideological pressure that limited the creative freedom. That is why the principle of historicism was important in the methodological basis of the work. It is

the principle of historicism, the consistent study and systematization of the material under study with its subsequent presentation, in accordance with a certain, pre-adopted periodization, allows us to consistently trace the processes taking place in the art environment and the development of the scientific component in the manufacture of ceramics.

The principle of consistency, which was used by the authors in preparing the materials of the paper, assumed the consideration of certain issues, in accordance with the sequence of processes that took place in such a popular variety of professional decorative applied art as art ceramics. Due to this approach, it was possible to focus on a detailed clarification of the ways of forming professional creativity in an inextricable connection, taking into account the characteristics of a certain material, the needs of appropriate material support, and the establishment of technological processes. Moreover, such a presentation of the material provided a clearer indication of the possibilities and prospects for the development of the mastery of art ceramics.

The processes taking place in art in general and the art of ceramics, in particular, were projected at the famous art center in Europe – Halychyna. When presenting factual material, the authors periodically carried out a comparative analysis and comparison of the local situation with individual historical events that took place during the beginning of the 20th century, difficult for the European world.

The foundation of the source base of the study is factual material collected during the meetings of the authors with lecturers and graduates of the departments of art ceramics of Lviv Academy of Arts, familiarization with museum collections, as well as relevant literary sources in Ukraine.

The main sources of acquaintance with the creative achievements of Lviv ceramic artists were the fund collections of Lviv museums: the Museum of Ethnography and Arts and Crafts of the Institute of Ethnology of the National Academy of Sciences of Ukraine, the Andrey Sheptytsky National Museum in Lviv, the Lviv Art Gallery. Some exhibits were found in the funds of the Lviv Historical Museum, the Museum of Folk Architecture and Life, the Lviv Museum of the History of Religion.

Results and discussion.

During 1900–1914, we observe the formation of the Galician version of the Ukrainian national style within the walls of the well-known design and production company of I. Levynsky in Lviv. It brought together the most prominent artists of the time: architects J. Zakharievych, K. Moklovsky, O. Lushpynsky, T. Obminsky, artists I. Trush, O. Novakivsky, M. Sosenko, sculptors P. Herasymovych, M. Havrylko, and decorative artists M. Lukyanovych, O. Biloskursky, P. Hlynchak, O. Kulchytska, and others (Radomska, 2019; Noha, 1997, p. 215). I. Levynsky's huge and powerful factory of construction and art industry united like-minded artists who designed and implemented numerous projects of architectural structures throughout Halychyna,

created samples of architectural and household ceramics, ceramics in the field of sacred art (Ivashkiv, 2020), tiles, varieties of facing tiles, etc.

In Halychyna, a group of artists, technologists who are constantly working in the field of art-and-industrial ceramics: A. Verner, J. Zakharievych, V. Krytsinsky, S. Dachynsky, L. Koshka, L. Marconi, Ye. Dubrava, I. Slovitsky, M. Lukiyanovych, H. Becher, and others, is gradually taking shape (Mateiko, 1959, p. 25).

Growing rapidly, the ceramic industry subsequently took one of the first places in the industry of Halychyna at the beginning of the 20th century. Ceramic enterprises were at a fairly high level of mechanization, the use of modern equipment. Halychyna was home to about ten highly efficient factories that were trying to compete with their products in the international market. However, in the first decades of the 20th century, only three ceramic firms had real international recognition in the field of art ceramics: the I. Levynsky's factory, the Kolomyia Pottery School, and the Regional Ceramic Research Station in Lviv. An important role in this was played by a kind of artistic style of decorating products, in which an attempt to use the motives of folk ceramics, the folk ornament is manifested (Shmahalo, 1994b, p. 29).

The early 20th century in the development of art ceramics was marked by the rapid development of the corresponding infrastructures. Art-and-industrial schools and production establishments, which constituted significant technical and artistic potential, were opened and operated. The range of ceramic products met international requirements. Facing tiles, ceramic sculpture, painting ceramic panels, decorative applied utensils, building and decorative bricks and tiles, a variety of tile products were of high art and technological quality. They were made in almost all possible ceramic materials – chamotte, maiolica, faience, porcelain, stone mass (Holubets, 1991b, pp. 13–14).

There were pottery centers that effectively "fed" professional ceramics in a number of towns and villages, including Belz, Halych, Hlynsk, Zolochiv, Zhovkva, Liubech Korolivska, Lviv, Potelych, Plisnesk, Staryi Sambir, Sokal, Stryi. The growth in the number of pottery workshops and craftsmen, starting from the 16th – 17th centuries, in many settlements of the region led to the emergence of separate guild organizations, expanding the market for products. Thus, separate potters' workshops were organized then in Lviv, Sokal, Sambir, Liubech Korolivska, Potelych, Yavoriv.

Products from each area of pottery had their own art features, which depended on the natural properties of raw materials, technological level of production, the stability of local traditions. All famous centers were famous for leading masters, bright creative personalities.

At the end of the 19th – beginning of the 20th century in the territory of Halychyna, the most famous folk pottery centers were: Lviv, Kolomyia, Kosiv, Pistyn, Horodok, Stryi, Oleyov, Sudova Vyshnya, Bilyi Kamin, Brody, Komarno, Kopychyntsi, Sniatyn, Sokal, Ivano-Frankivsk, Tysmenytsia, Zolochiv, Zhuravno, Zhyvtsi, Hlynske, Mykolaiv, Halych, Yavoriv, Potelych, Shpykolosy,

Havarechchyna, etc. The main centers for rethinking folk style trends were Horodok, Kolomyia, Kosiv, Sokal, Potelych, Halych. They had their own original examples of interpretation, both in terms of shape and decoration of products. The ceramic products of these cells impress with an infinite variety of forms created on the basis of a fine understanding of the specific properties of the ceramic material. Ways of creating generations of expressive decorative image masters in folk ceramics, which has mostly utilitarian purpose, were constant role models for professional artists of Halychyna in the early 20th century (Holubets, 1991b, p. 10).

Folk masters had many techniques for decorating and shaping the ceramics. Smoking and polishing are one of the oldest techniques typical of many pottery centers in Ukraine. It gives a unique decorative effect and contributes to the maximum detection of plastic, silhouette lines of pottery. From time immemorial, folk masters of Halychyna used the method of partial coating of products with glaze. The combination of an ocher or grayish-brown surface of the shard with shiny glaze streaks, most often light green, dark green, or yellow, created a kind of decorative effect. Free design, not repeating on every piece, emphasized its man-made nature. They also skillfully used such a widespread technique as flyandrovka (Mateiko, 1959, p. 77). The use of technological methods that allow to obtain an unusual color, special decorative effects, an interesting shape and texture, brought to high perfection by many years of experience, is observed in the art-and-industrial centers of Lviv, Potelych, Halych, Kosiv, Kolomyia, and other centers of ceramic production (Mateiko, 1959, pp. 80–81). A characteristic feature of the decor of Ukrainian folk ceramics is the use of not one, but simultaneously several methods of decorating it, for example, engraving and painting with engobes, engraving and painting with ocher, engraving and painting with a horn, engraving and polishing, engraving and glazing, etc.

In addition to the simplest, exquisite in silhouette and proportions of products – jugs, makitras, bowls, which were shaped as a single volume during the rotation of the potter's wheel, folk craftsmen created a variety of figured vessels – kumanetses, pleskanky, water bottles, small barrels, candlesticks, as well as vessels treated in the form of animals (so-called lembics) or anthropomorphic volumes in the form of humans. They were mounted from several turned forms, they were distinguished by the tectonic unity of the main volume and details, expressiveness of silhouette lines. They are characterized by generalization and emphasized decorative forms, witty adaptation to utilitarian needs, vivid imagery. The ability to convey the pictorial motif with the help of minimal means is clearly manifested in the ceramic sculpture of small forms, in particular in the toy.

Sokal was an outstanding center, which has long been famous for painting on ceramics. In terms of technology, the products of the Sokal potters are very close to the Hutsul ones: an engraved drawing was applied on a white background (an engobe-covered crock), according to which the painting was done mainly in three colors – brown, green, and yellow. The finished product was covered with a

transparent glaze. Real masterpieces of folk art, which are kept in many museums, were created by the famous master from the city of Sokal Vasyl Shostopalets (Pokotiuk, 2017). Unusual in shape (pear-shaped banyaks and twins) and decor (engraving, engobe painting, and green glaze floods) products of this master deserve attention. In addition to traditional items turned on a potter's wheel, he decorated original anthropomorphic vessels with characteristic paintings (Figure 1). The dominant grotesque intonations determine the emotional sound of the decorative images of his authorship (Holubets, 1991b, p. 11).

Figure 1. A jug made in the form of a noble lord. By Vasyl Shostopalets (Pokotiuk, 2017).

One of the traditional forms of pottery is zoomorphic utensils, so-called lembics. The boundless imagination of their performers, the ability to convey the characteristics of animals in constructions of simple geometric volumes, turned on a potter's wheel, complemented by sculpted details and paintings is impressive.

Along with a variety of forms and purposes of dishes, folk artists created sculptural sculptures, ceramic toys. One of the famous centers in Lviv Region, where ceramic toys have long been made, was the village of Stara Sil. Cute tin whistles and rattles were made in the form of hollow clay balls, figurines of birds, animals, and people. The image of a rider on a horse was very popular. The maximum

generalization of forms, the simplification and schematic nature of the plastic solution did not interfere with the expressiveness of movements, the reproduction of the characteristic features inherent in the prototype of the depicted. In some cases, terracotta items were decorated with engobe painting formed by parallel or concentric stripes, sometimes covered with colored glaze.

A significant influence on the ceramics of Halychyna, and in particular – on Lviv ceramics, was exerted by the very popular Hutsul folk ceramics in the western regions of Ukraine, where, in the system of polychrome decor, along with floral ornaments, animal drawings, there were images of human figures and, sometimes, complex plot scenes. The peculiar figurative language of the primitive allowed for a conditional interpretation of the depicted, deformations and violation of real proportions. It is characterized by bright grotesque characteristics, expression of movement, narrative composition, which allows one to compare events of different times. Filling the entire surface of ceramic products with colorful decor, the Hutsul craftsmen, as it were, turned it into a living space for plants, animals, people, merging into a harmonious whole in a single decorative structure (Holubets, 1991b, p. 12).

As you can see, Galician ceramics of the first third of the 20th century rests on a solid foundation created by folk clay masters, who have a subtle understanding of the nature of the material, its specific capabilities, master ability to use technological methods of shaping and decoration. At the same time, a certain decline in the development of folk cells of ceramic production, which occurred during the expansion of the infrastructure of art-and-industrial ceramics, under the influence of socioeconomic factors of the time, should be noted.

The art-and-industrial societies, workshops, plants, and factories, as well as art-and-industrial schools created at the end of the 19th century were of great importance for creating new principles of art ceramics of Halychyna in particular and the nature of the national art of the early 20th century. But it was under them that the first ceramic associations were subsequently founded.

The largest center for the training of art specialists in Halychyna was the Art-and-Industrial School in Lviv. Established in 1876 as a School for Drawing and Modeling at the City Art-and-Industrial Museum, it initially did not have its own premises. In 1909, the School received a large, specially erected house at 47 Snopkivska Street. Pupils and graduates actively participate in exhibitions "organized annually within the walls of the institution itself and in exhibitions of national importance in Vienna (1880, 1889), the Regional Exhibition in Lviv (1894), in the exhibition of metal art products in Prague (1912), and other events" (Maksysko, 1974, p. 115). The educational institution was constantly increasing, "In the 1911–1912 academic year, the number of teachers in the School increased to 38 and the total number of pupils – up to 600. At that time, the School employed such well-known artists of Halychyna as A. Auhustynovych, J. Nalborchyk, S. Batovsky, O. Beltovsky, P. Herasymovych, Z. Horholevsky, T. Rybkovsky, Z. Rozvadovsky, V. Krytsinsky, S. Reichmann" (Shmahalo, 2005, pp. 9–11). Among other

specializations, the Department of Art Ceramics occupied a prominent place, "It was founded in 1892 with a specialization: building ceramics, art of creating tiles, pottery functional ceramics. The laboratory, ceramic shops, and kilns of I. Levynsky's factory were used in the training process (Figure 2), although there were shops and equipment. Training programs were provided by high-class specialists of the enterprises of the whole region" (Levkiv, 2002, p. 56).

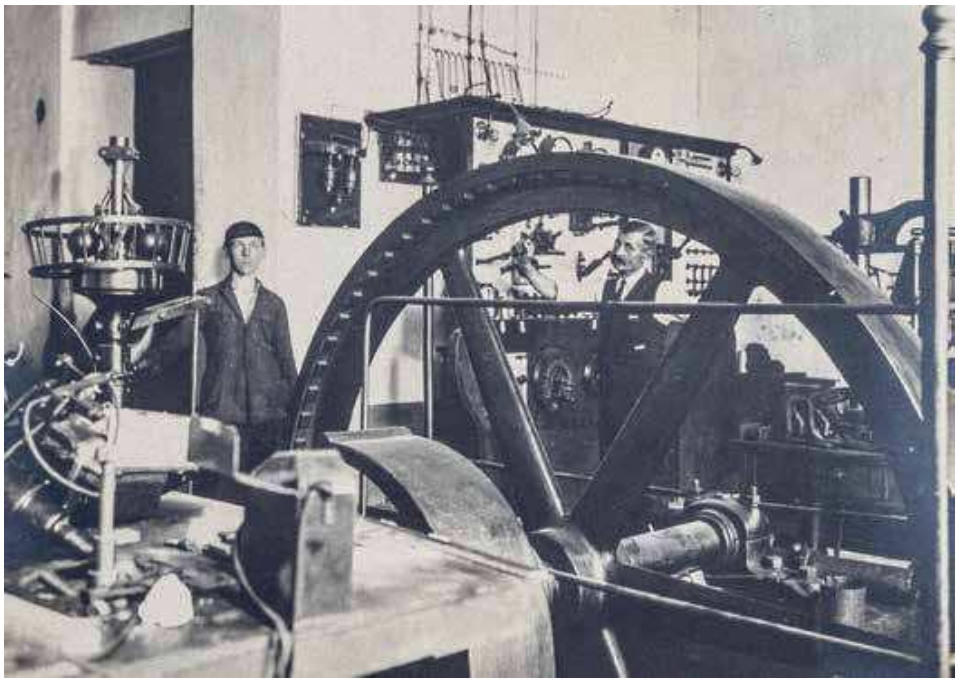


Figure 2. Electromechanical department of I. Levynsky factory (Klimashevskyi, 2020, p. 84).

It should be noted that the mentioned art institution functioned during the Second World War. Then, with the direct initiative and support of the Ukrainian Central Committee, the first Ukrainian-language art school – the State Art-and-Industrial School – was established in Lviv. Under the leadership of M. Osinchuk and later – E. Nahirny, it existed in 1941–1943 under one roof with a similar Polish educational institution, the director of which was J. Stazhynsky. Experienced artists and teachers taught at the school: M. Butovych, V. Balyas, M. Vnuk, M. Kmit, A. Malyutsa, M. Osinchuk, M. Fedyuk, M. Mukhin, O. Povstenko, and others. The composition of the student body was indicative for that time, "Many were driven to Lviv by the war. Some fled east of the Germans, others west of the Soviets. One and the other were united by Lviv, a city between two forces" (Zvirynskyi, 1997, p. 68). During the years of German occupation, the School's students were well-known future artists and cultural figures: M. Batih, J. Zakharchyshyn, K. Zvirynskyi, L. Krushelnytska, S. Koropchak, V. Patyk, V. Yarema, and others.

By the end of World War II, the State Art-and-Industrial School was redesigned into a construction school, "...Most of the students refused to continue their studies at

the new school and when, in October 1943, a recruitment was announced for the newly created Higher Art Studio headed by Vasyl Krychevsky, a significant number of students moved there" (Zvirynskyi, 1997, p. 68). The founders interpreted the new institution as the continuer of the traditions of the Ukrainian Academy of Arts in Kyiv. With the advent of Soviet power, in 1946, on the site of the former art-and-industrial school, the Lviv Art School was created with a total of about 100 students.

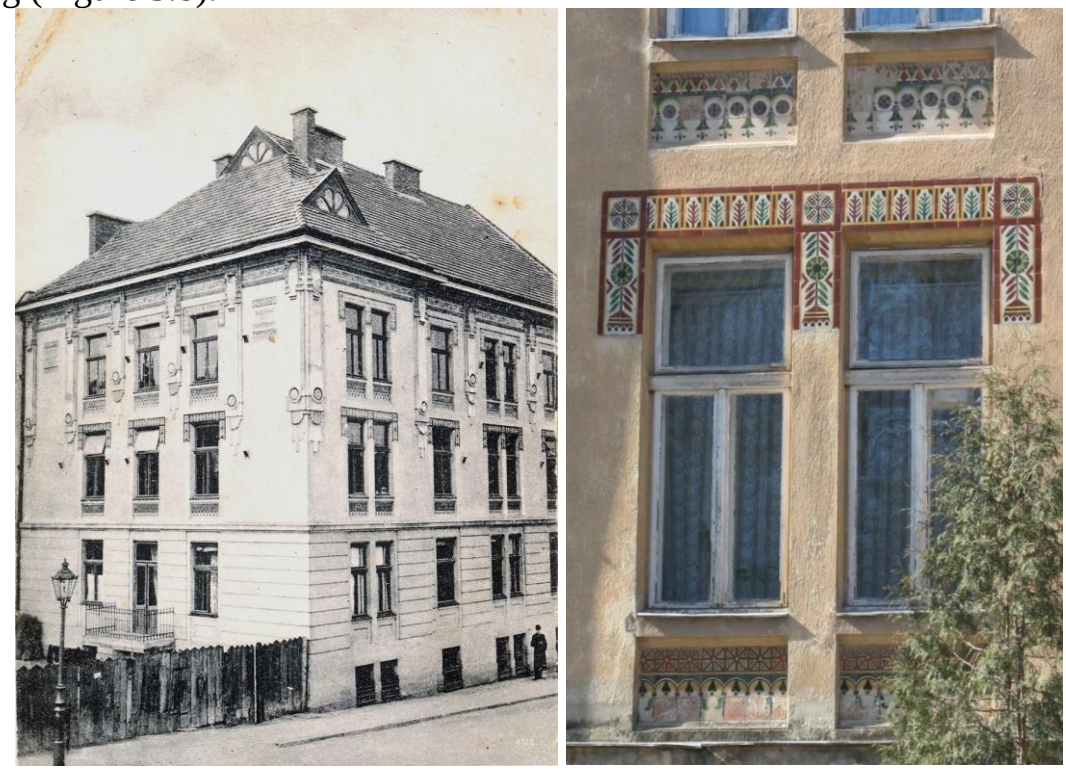
Returning to the situation at the beginning of the 20th century, let us first of all note the facts that members of newly created societies and art-and-industrial workshops organized numerous competitions, exhibitions of the best examples of ceramics, etc. So, in 1907, under the leadership of I. Levynsky, the "Russian Ceramic Circle" was founded. This Circle brought together Ukrainian engineers, technicians, artists who worked in ceramics not only in the territory of Halychyna, but also beyond. It was the first all-Ukrainian technical artistic organization. Subsequently, other associations of artisans and industrialists appeared – the "Meshchanske brotherhood" (1909), "Lviv Rus" (1909). In 1918, an important event in the life of Western Ukraine was the founding of a new organization – the Labor. Already at the beginning of its activity, it undertook the revival of a ceramic factory in Lviv (Noha, 2001, p. 45).

It is worth noting that the search for "Ukrainian style" continued at the turn of the 19th and 20th centuries at enterprises that produced porcelain and earthenware, in particular, in Volyn. Flattened forms of teapots borrowed from the 18th century, Korets and Zhovkovsko-Hlynsky production, decorated with a weaving of ornament from a golden runner with a thin truncated chain, "survived" at the Baranivka Porcelain Factory until the beginning of the 20th century. At the turn of the century, the Baranivka production facility made fruit vases on an elongated stem using the cutting technique, which were decorated with iridescent paints applied using an airbrush (Shkolna, 2008, p. 121).

However, the largest center for the production and use of decorative ceramics was the architectural firm of I. Levynsky. The beginning of the 20th century was the period of its highest prosperity. At the heart of the creative method of the artists who worked at the enterprise, the age-related achievements of folk art were effectively used and rethought. The building and art ceramics factory of I. Levinsky began work in 1888. A distinctive feature of the products produced was an orientation towards local folk art, a bold interpretation of borrowed motives, "The forms, ornament, and color (brown, yellow, green colors), traditional for Western Ukrainian ceramics, were preserved, but, at the same time, the decorative sound of the entire product as a whole was dramatically sharpened. The color was enriched with different shades of tones, especially previously unconventional – purple, blue, gold. The decor was intricately thickened, stylized folk motifs were combined with typical Art Nouveau patterns. In the art and plastic form of decorative applied ceramics, there is the interpretation of the plastic solution, color decor and technology of Hutsul ceramics and ceramics of the Sokal pottery center" (Kolupaieva, 2004, p. 245]. The decor system was

dominated by strict calculation, constructive clarity, and geometric accuracy, as well as crafted rhythms. The basis of the ornament was the intersection of straight or concentric lines that formed a graphic grid, each element of which was filled with a certain color. The dominant light background gave the products a characteristic lightness and its combination with polychrome painting – solemn sublime intonations. An important contribution in this area was the activity of O. Biloskursky. The compositions of his ceramic friezes and panels are based on elements of Ukrainian ornaments – rhombuses, crosses, stylized ears of wheat, sunflowers, motifs of Hutsul embroidery patterns. The facing tile of O. Biloskursky made according to folk models, was used in construction throughout Halychyna.

Yu. Lebishchak, who was one of the first to use the national color in the ornamentation of facing tiles, also worked at the factory. He opened his own ceramic workshop, which made thematic and ornamental tiles based on the traditions of Ukrainian folk painting. O. Lushpynsky worked in the same direction at I. Levynsky's factory. According to his drawings, ceramic decorations were created for the house of the Dyakivska Bursa at St. George's Cathedral in 1903 (Figure 3.a). These were window-sill ceramic inserts and above-window "towels", the rich color and expressive drawing of which became the main accent in the composition of the building (Figure 3.b).



a b

Figure 3. The house of the Dyakivska Bursa at St. George's Cathedral: a – photo of 1904 (Lehin, 2019); b – fragment of the facade decor in the photo of 2010 (Pleshakov, 2010).

The I. Levynsky factory has undertaken an important mission of reviving the art of tiles. The folk art of creating tiles fell into decay at the beginning of the 20th century. It is being revived at the industrial level due to the efforts of the tile department of the I. Levynsky factory under the leadership of Dzbansky, who took as a basis the plot-thematic solution and technological methods of Hutsul tiles. This is, first of all, the work of famous folk artists – I. Baranyuk and O. Bakhmatyuk. The first attempts in this direction received approving reviews at exhibitions in Paris (1900), Kraków (1905), Kolomyia (1911). One of the most interesting examples of I. Levynsky's Lviv factory was a kiln made in the folk style designed by E. Kovach for the Galician pavilion at the 1900 World's Fair in Paris.

A separate direction in the creation of tiles is their ornamentation, which is based on the decoration of the traditional motif of the "tree of life", the characteristic patterns of folk embroidery. Such a tile kiln was demonstrated at the Kraków Exhibition in 1905. Elements of folk ornamentation in relief ceramic tiles in Halychyna were also used in factories in Hlynsk, Kolomyia, Halych, Lviv.

Factory artists were looking for new forms of ornament, somewhat abstracted from a particular variety of decorative applied art. That is why you can see the motifs of embroidery, weaving, beadwork, wood carving, or engraving on metal, patterns of Easter eggs in their ornaments. There are interesting improvisations in the combination of form and painting, but there is always a certain pattern: the ornament is mainly concentrated in places of greatest plastic stress – on the convex walls of vessels, near the edges of the neck, unfolds in dynamic concentric motion on plates.

The activity of ceramists O. Biloskursky and M. Lukyanovych is indicative in this respect. They developed ornamental versions of compositions based on the art stylization of pottery of Hutsulshchyna, Boikivshchyna, folk centers of Lviv, Ternopil, the best examples of ceramics from Opishnia. These artists used embroidery ornaments, wood carvings, transforming them into ornamental subjects for replicated ceramics.

Analyzing the processes that took place at the beginning of the 20th century, it is worth mentioning the pottery school in the village of Vikno, which was organized in 1880–1886 by V. Fedorovych. Its works have been successfully exhibited at many exhibitions. The head of the school was a local priest M. Tchaikovsky, who made many efforts to revive the traditions of pottery, while providing local craftsmen with samples of ornaments with Christian symbols.

At the beginning of the 20th century, Halychyna pursued a policy of Ukrainization of the church and hence church art, which was used in the decoration of temples. This movement was led by Metropolitan Andrey Sheptytsky. Through the efforts of such artists as O. Lushpynsky, E. Kovach, T. Obminsky, L. Levytsky, in particular, the production of ceramic Easter eggs was organized. They were made of ceramic mass by casting in gypsum molds. After firing, they were painted with ceramic paints and fired again. The ornament was of a vegetable nature. The color scheme usually involved a combination of black, brown, and yellow colors.

At the beginning of the 20th century in Lviv, Kolomyia, Kosiv began active production of ceramic icons. O. Lushpynsky also undertakes their creation (Figure 4) (Kolupaieva, 2012).

Figure 4. Oleksander Lushpynsky. Icon. Clay, engobes, glaze, molding, painting. I. Levynsky's factory. Beginning of the 20th century. 56×45×4cm. National Museum in Lviv. Andrey Sheptytsky (Kolupaieva, 2012).

At the same time, in the architectural production workshops of the firm of I. Levynsky, they were developing projects for ceramic icon cases. In particular, the icon case, which combines wood and glazed ceramics, was designed by O. Lushpynsky. The icon case was ornamented with Hutsul carvings, with an image – a triptych of the image of Christ and two angels executed in majolica. The art image was based on the successful combination of ebony and brightly glazed ceramics. The icon case was presented in Lviv at the 1909 exhibition of religious products. At the factory of I. Levynsky, projects for other items of church furnishings were also developed, in particular, terracotta and glazed church crosses, in the decoration of which ones used the ornamentation of woodcarving, characteristic of Hutsulshchyna and Boikivshchyna (Baran, 1993).

Appreciating the ceramic art-and-industrial production of Halychyna from the 1910s – early 1940s from an art criticism point of view, several form-making style trends can be distinguished. Most of these directions do not have a specific time reference, because they were created not only according to the art preferences of artists, but also according to certain laws of the market environment, in accordance with changes in the sociopolitical situation, which included the factor of a certain provincial distance of Halychyna from the main European centers. Furthermore, the difficulty of defining certain stylistic trends in a holistic system of art-and-industrial ceramics of Halychyna is due to the absence in ninety percent of cases of a specific

temporary attribution of ceramic products. The printed materials of that time often give conflicting conclusions. So, experts distinguish: 1) an eclectic style (60s of the 19th century – 20s of the 20th century) with a focus on: a) the antique art; b) the art of Japan, China, and other countries of the East; c) school of styles of European art of the 6th – 19th centuries; d) Ukrainian folk art; 2) the style of secession (late 90s of the 19th century – 10s of the 20th century); 3) avant-garde searches (1905–1940s) (Noha, 2001, pp. 215–216).

Many of the most prominent artists of the time contributed to the formation of the above-mentioned style of ceramics: architects V. and Ye. Nagirny, J. and A. Zakharievych, O. Lushpynsky, L. Levynsky, T. Obminsky, and Ye. Chervinsky; painters I. Boychuk, I. Trush, O. Novakivsky, M. Sosenko; sculptors L. Marconi, P. Herasymovych, M. Havrylyuk, P. Paraschuk; applied artists M. Lukiyanovych, O. Biloskursky, Yu. Lebishchak, and others. All these artists were to some extent related to ceramic centers (Noha, 2001, p. 237).

On the numerous samples of art-and-industrial ceramics created in the 1910s, it is possible to determine the typical techniques and methods of decoration that characterize the Galician version of Art Nouveau in ceramics based on the Ukrainian folk style, including the construction of forms on the folk Hutsul and Boykiv ceramics, a kind of flavor inherent in local potters, borrowing motives from the works of Ukrainian folk arts and crafts, etc. Regarding the use of elements of folk ornament and its stylistic transformation in tiles, art of creating tiles, etc., during this period, all the largest institutions of Halychyna in Lviv, Kolomyia, Halych, Tovsty, Hlynsk manufactured products of this type. From the point of view of art history, these were the tendencies of combining the stylistics of modernism with the traditions of folk art. In the art of creating tiles, the artists of Lviv Region showed themselves the most (among them it is worth mentioning first of all Edward Kovach). Their work became the basis for the creative development of artists who worked in the 20–40s of the 20th century.

At the beginning of the 20th century, I. Levynsky's ceramic factories created ornamental ceramics for decorating buildings, which determined the future search in this direction for artists from all over Halychyna. First of all, we mean facing tiles for Dyakivska Bursa (1903–1904), for the house of the Dniester Society (1904–1905) in Lviv, the People's House in Kitsman, and for a number of other houses of national societies and "Prosvita" in Halychyna (Holubets, 1991a).

The introduction of Ukrainian folk motifs into building structures and architecture, characteristic of Art Nouveau, in Halychyna influenced plastic decor and sculpture. Such manifestations can be seen in the decorative plastic design of the exteriors of houses. Such attempts are recorded in the sculptural design of a number of facades, where attempts to plastic transfer of structural elements of the log-house Hutsul houses are palpable. These are, in particular, houses on 44 Shota Rustaveli Street and 103 General Chuprynka Street in Lviv. Sometimes sculptors borrow ornaments from folk decorative applied art for their projects (houses on 11 General Chuprynka and 20 Rus'ka Street in

Lviv). This is the transformation of embroidery elements in the stucco molding of balconies. As a whole, floral ornamental motifs were used in the plastic decor, in particular images of sunflower and wheat, symbolic for Ukraine.

A separate area for searching ceramic artists is the art of creating tiles. The beginning of its industrial development falls on the late 1880s – early 1890s, when we can talk about the presence of about 50 enterprises for the production of tiles. According to materials from that time, one of them produced 5,000 kilns annually; four enterprises – 1,000 pcs. each; six ones – 500 pcs. each; the rest ones produced less. However, only a few firms were of primary importance for the development of Galician art of creating tiles. These are, first of all, the Lviv factory of I. Levynsky (Figure 5), the factory of J. Zakharievych and L. Verner in Hlinsk, and the Kubin, Brekh: Korzheniovsky company in Lviv. It was these enterprises that produced not only the largest number of products, but also carefully monitored its quality, which was evidenced by the numerous awards of their products at international exhibitions in Lviv, Odesa, Kraków, Paris, and other European cities (Noha, 2001, p. 105).

Figure 5. Press for the manufacture of tiles at the factory of I. Levynsky. Archival photo (Klimashevskyi, 2020, p. 165).

At the turn of the 19th and 20th centuries, Galician tile makers produced mostly dark plastic kilns (red, green, or brown) decorated with convex ornaments in an

eclectic style. Ceramic tiles for such kilns were produced in plaster molds and the molds themselves were cast made from models by local sculptors. In the absence of local samples, kilns molds were imported from abroad, mainly from Germany (Dresden and Berlin), where there were factories for their production.

As for the introduction of a kind of stylistics in the art of tile focused on Ukrainian folk motifs, the "fashion queen" has always been the factory of I. Levynsky. Factory artists O. Biloskursky, O. Lushpynsky, M. Lukiyanovych, Ye. Kova developed samples of kilns, which were very successful both at exhibitions and among ordinary buyers. The original compositions of the kilns produced here were of high quality and they were presented at exhibitions in Lviv in 1892 and 1894. At these exhibitions, local and foreign exhibits preferred kilns of two other factories: J. Zakharievych and A. Verner, as well as Kubin, Brekh: Korzheniovsky. At this time, the quality of their products has increased so much that they have successfully competed with Western companies not only in Lviv, but also in the provinces (Noha, 2001, p. 109–110).

Interesting decoration of ceramic tiles based on folk motifs was shown at the mentioned exhibitions by Levynsky from Lviv and Hlynsk – painted ceramic tiles on a colorful background. Their production took place in the following sequence: ceramic tiles with relief ornaments baked for the first time were painted with pre-glaze paints, after which they were covered with transparent glaze and baked again. The play of chiaroscuro relief and color painting created an additional aesthetic impression. This decoration method, together with the usual glaze, marbling and dripping techniques, has since found widespread use in Halychyna (Noha, 2001, p. 110).

At the beginning of the 20th century, the process of development of Galician art of creating tiles took place through constant artistic and technical improvement of products and technological equipment (Figure 6). During these years, a new method of making ceramic tiles "porcelain imitation" was invented. It consisted in "whitewashing" of ceramic tiles – a thin layering of white clay on a baked product, followed by glaze coating. After baking, a milky white color, reminiscent of the products from Berlin, which were supplied to Halychyna in large quantities, was obtained. After many years of searching at the factory of I. Levynsky, the glaze of the desired color was created and since then Halychyna has begun to produce white kilns.

The use of elements of folk ornament in relief and painted ceramic tiles of the first half of the 20th century in Halychyna is found in factories in Hlynsk (near Lviv), Kolomyia, Halych, and Lviv. Mostly these were traditional modern schemes with the use of folk ornaments, made in gray, green, cherry colors.

At the turn of the century, art-and-industrial ceramics of Halychyna spread in the field of mass production of ceramic plastics. By this name, we mean busts, statuettes, vases, products with embossed decoration, sculptural embossed tiles, embossed facade panels, and much more. Such products were made in a wide range in Eastern Halychyna, mostly in several firms: at the enterprises of I. Levynsky in Lviv (1889–1914), the Regional Station of Ceramic Experiments (1894–1914), the Patsykiv

Faience Products Factory of Oleksander Levytsky (1912–1941) (Shmahalo, 2005, p. 171). It should also be mentioned that such works in the late 19th – in the first half of the 20th century were periodically created by sculptors of the Lviv Art-and-Industrial School (Shmahalo, 2005, pp. 174–175) and the pottery school in Kolomyia.

a b

Figure 6. – I. Levynsky's factory: a – kiln for baking a tile (Klimashevskyi, 2020, p. 166); b – press in the tile department of I. Levynsky's factory (Klimashevskyi, 2020, p. 168).

There were three main lines of sculpture production at the enterprises of I. Levynsky. The first one presented works of ceramics, such as figurines, busts, relief tiles, friezes, funerary monuments, terracotta and majolica plaques, relief plates, etc. The second one was associated with sculpture, which was made as an element of the interior or souvenir products – busts, plaques, sculpture toys. The third direction – sculptures made of chamotte or artificial stone, mainly bas-reliefs and high-reliefs, less often – round sculptures, as a rule, for exteriors and interiors (Holubets, 1991a).

The sculptural products of I. Levynsky factory gained considerable popularity. The sculptors of the factory developed and launched into production, along with decorative applied art and ceramic tiles, things of a purely pictorial direction: plaques, portrait busts and figurative images, funerary monuments, sculptural reliefs made in terracotta or majolica. Elements of architectural and decorative finishing have found wide application not only in Western Ukraine, but throughout Poland, and objects of fine art were highly appreciated at sculpture exhibitions (Shmahalo, 1995, pp. 50–54). Among the plaques popular at that time, we have note the plots "Meeting of the

Hutsuls", "Peasants and the Jew". The original ceramic tiles-plaques were created by the sculptor O. Dzhulynska: "Lyre Player and Peasant in the Field", "Peasant in the Field Eats His Lunch", etc.

It should be noted that the production of sculptures and small plastics was typical of many centers of ceramic production in Halychyna. In particular, the sculpture was made in Liubech Korolivska, Potelych, and others. The same products were made in various centers of folk pottery. Thus, small figurines, plastic, children's toys were made in the Stara Sil. This was mainly done by women of potters.

Kolomyia Pottery School, being at the same time a production institution, also turned to the production of ceramic tiles, plaques, relief tiles, which were used in construction (Shmahalo, 2005, pp. 172–173; Shmahalo, 1991, pp. 57–58). The additional art potential of the School in Kolomyia, in addition to teachers and students, were numerous artists from Lviv, who often worked here, especially in the first years of the 20th century.

Before the First World War, the Faience Factory in the village of Patsykiv (now the village of Pidlissia, Ivano-Frankivsk Region) founded by Oleksander Levytsky enters the arena of ceramic factories in Halychyna. During the period of its existence (1912–1942), the factory produced faience and majolica products designed by Lviv sculptors, such as L. Drexler, A. Popel, O. Levytsky, Yu. Khmelinsky, S. Chapek, and others.

In the period from the beginning to the 40's of the 20th century, Halychyna enterprises mastered the production of a wide range of products in the field of ceramic plastics – anthropomorphic and animalistic statuettes, small sculptural compositions (busts, portrait sculptures, figures, reliefs, bas-reliefs, funerary monuments, plaques); products of architectural and construction purpose (columns, vases, compositions, tops to architectural details, relief tiles, relief tile panels); household products with embossed decor (vases, bottles, plates, jugs); children's toys ("little horses", "lambs", piggy banks, animalistics) in different materials (terracotta, majolica, faience, stone, porcelain, etc.) (Shmahalo, 1995, pp. 50–51).

As we can see, ceramic plastics, which were made in the art-and-industrial institutions of Halychyna in the early 19th – first half of the 20th century, was characterized by a variety of range and stylistic concepts.

As already mentioned, at the beginning of the 20th century, O. Lushpynsky turned to the creation of ceramic icons (Noha, 1993, p. 73). Works of this nature clearly testify to the involvement of ceramics in the field of contemporary searches for new formative means in the national religious art (Shmahalo, 1994b, p. 78). In particular, the majolica icon of I. Levynsky's factory from the funds of the National Museum in Lviv The Coronation of the Blessed Virgin Mary represents attempts to create ceramic images on the basis of Byzantium with the formal language of modernism.

The creative search also continued in line with the combination of traditional iconography and aesthetics of folk ornamental art, taking into account the peculiarities of

materials, industrial production, and modern spiritual needs. Sacred ceramics in the first decades of the 20th century were made in other institutions of professional ceramics, for example, in Kolomyia Pottery School (Shmahalo, 1994a, p. 45).

In folk ceramics of the early 20th century, the production of ritual and ceremonial utensils, which were used in family and calendar ceremonialism, was widespread. The availability of products directly intended for the arrangement of temples and the celebration of liturgy is due to religious requirements and regional features of pottery. In such products, which are characteristic first of all of the ceramics of Prykarpattia, the connections with the sacred Christian art were more clearly revealed (Kolupaieva, 2004, p. 248). The use of utensils in traditional rituals, apparently, dates back to ancient times and contained features of traditional folk pottery. The typology of products covered all the main groups and types of utensils known in traditional pottery. They had a specific function and local names.

Everywhere there were "lean pots", "lean dishes" – dishes in which ritual meals were cooked three times a year. For holy water, ones made jugs, konovochky (Hutsulshchyna) (Shukhevych, 1904, p. 203); in the Easter rite, bowls were used for "bringing" to the church, "bowls for the consecrated". Ones also produced polished supplies or vases for kutia and cheese, reminiscent of deep bowls with tires, paskivnyky – baking dishes for paskas (traditional sugar-topped Easter cakes), painted ceramic baskets, etc. Ritual utensils have always been distinguished by their thoroughness of shaping and ornate décor (Kolupaieva, 2004, p. 249).

Ritual items similar to censers are unique. These are closed bowl-shaped vessels with lugs, through slits of various configurations (in the form of an arch, a cross, a circle, or a triangle), topped with a malleable cross. Such products are especially common at Hutsulshchyna – in Kolomyia and Kosiv. Kolomyia "chagans" are not covered with glaze, mostly smoked, decorated with plastic-figure techniques (engraving, polishing), cord ornaments, figured slits. They were used as candle lanterns. Such lanterns were made by masters from the well-known Kahnikevychi family in Kolomyia (Baran, 1993). There were also candlesticks with a decor of more difficult construction: rosettes, circles, flowers, sinusoids-runners, zigzags, dentels of a lambrequin, planes of "fir-tree writing" (in the form of a fine lattice with oblique intersecting lines) (Lashchuk, 1956, p. 20). Characteristic of candlesticks of Halychyna was the alternation and combination of floral and geometric ornaments. High invariance of grouping of graphic, color solution of elements on the basis of contrasting comparisons of yellow, green, brown colors on a white background (Kolupaieva, 2004, p. 253).

In the 1930s, Kosiv potters M. Sovizdranyuk, H. Kuryliuk, and P. Tsvilyk made ceramic painted aspergilliums with a bas-relief image of the Crucifixion (Kolupaieva, 2004, p. 255).

On Halychyna, ceramic aspergilliums, created only for Catholic and Greek Catholic churches, are noted for their originality. They demonstrate the diversity of

the general forms of these small pottery products, the connection with Christian iconography and its popular understanding.

The development of the art of ceramics in Halychyna is inextricably linked with certain personalities. We have already mentioned I. Levynsky, many architects and artists who worked with him. Let us also mention the well-known figures in the development of ceramic production of Halychyna – Casymir, his sons – Oleksander and Joseph (Jacob) Levytsky. The beginnings of their activity date back to the middle of the 19th century. In 1900, C. Levytsky opened the so-called "Porcelain and Glass Painter" in his shop in Lviv. C. Levytsky's workers painted dinnerware sets and individual products, according to the projects of well-known Galician artists (E. Kovach and others). From the first years of the 20th century until 1939, they gained considerable popularity. Using the professional artistic potential of Lviv, its owner managed to overtake in the artistic sense of two larger similar institutions – in Brody and Kraków (Shmahalo, 2005, p. 171). Somewhat later, in the 1910s, by the activities of the Levytsky brothers, a faience factory was founded in Patsykiv, which produced utensils, sculptures, etc. A characteristic feature of this ceramic enterprise was a marked simplification of the form of both functional and decorative items. The company's products were mostly focused on meeting the needs of the general public.

Also worth mentioning is the pottery workshop of functional ceramics in Halych, which was headed by one of the future leaders of ceramic production in Ukraine Yuriy Lebishchak. The workshop designed and manufactured bowls, vases, jugs, bottles, etc.

Technological discoveries make up a significant part of the achievements of professional ceramics of the first half of the 20th century. So, for example, from 1906 to 1914, production of high-quality color mass (similar to modern technical porcelain) was introduced at the enterprise of I. Levynsky. Small painted bottles, vases with embossed subjects, boxes, and other small things were created from this material by casting. In 1914, the factory made products from almost all ceramic materials (Holubets, 1991a). The wide technological range gave an impressive breadth of the range: vases (decorative for plants), pot holders, ashtrays, bowls of different sizes, makitras, plates of different sizes, strainers, flacons, pots, jugs, hladushchiky, "babnyky", paskivnyky, tea sets, coffee sets, plates, trays, "twins", "triplets", "quadruplets", milk jugs with a handle-holder (on three or four legs), "pampushnytsi", kumanetses, pleskanky, water bottles, banyaks, small barrels, flasks, bottles, cups, glasses, figured dishes (roosters, rams, lions, anthropomorphic crockery), toys for children as a crockery (bowls, plates, cups, twins, etc.), or plastics ("fuzzballs", "cones", "balls", etc.), technical utensils.

At the beginning of the second decade of the 20th century, the development of professional ceramic art of Halychyna was actively influenced by the establishment of cultural contacts with Eastern Ukraine (Shmahalo, 1999, pp. 155–157). The exchange of information about the creative achievements of Eastern and Western Ukraine takes place both through participation in joint exhibitions and through the

practical exchange of technological and art experience in connection with migration processes. A large number of specialists from Halychyna worked in the leading ceramic centers of the Eastern Ukrainian lands and, on the contrary, artists from Eastern Ukraine worked at the ceramic enterprises of Halychyna. This resulted in the effective use and mutual enrichment of traditional decorative forms of different regions of Ukraine. It is important to note that the representatives of the Galician centers of art-and-industrial ceramics actively disseminated in practice the technological heritage of the western regions of Ukraine in the east of our country.

In addition to mutual enrichment at the technological level, the migration of artists and sculptors between the ceramic centers of Eastern and Western Ukraine, which were divided by the State border, led to the identification of a nationwide art style based on well-known local art manifestations that received various names: "Hutsul", "Galician", "Poltava", "Little Russian", "Kolomyia", "Lviv", etc.

An example of Galician introduction of art stylistics and technological knowledge to the eastern territories was the activity of ceramists M. and O. Biloskursky, Yu. Lebishchak, S. Patkovsky, H. Berezovsky, who worked in the ceramic centers of Eastern Ukraine and Russia (Noha, 2001, pp. 254–255). It should be noted that the active work of these and many other Western Ukrainian artists has led to the fact that some products of the centers of ceramic art of Eastern Ukraine are marked by features of borrowing from Hutsulshchyna.

Talking about the effectiveness of relations between Western and Eastern Ukraine, we note that, on the other hand, the general situation in Halychyna 1900s – 1940s is characterized by a significant presence in many processes of Polish experts. The Polish-Ukrainian and Ukrainian-Polish relations at that time were obviously difficult, but they were marked by an organic and inseparable unity in many cases of the representatives of both nations. Their joint work is felt in the activities of many organizational structures.

A typical example is the Regional Ceramic Research Station created at Lviv Polytechnic (1886) (Shmahalo, 1999, p. 151). Under its professional guidance, production was organized in pottery schools in Kolomyia (1886), Tovsty (1886), Porembije (1880s), Podzuje (1889), and in the ceramic enterprises of Halychyna. Many high-ranking officials took part in the processes of its creation (1890s) and activities. This fact puts the organization in first place among similar institutions in the region. Significant merit in the activities of the Station lay in the titanic tireless work of Edmund Krzhen and Professor Julian Zakharievych. Ceramic engineer E. Krzhen, leading scientific research from the very beginning, raised them to the highest level. He and his colleagues and students developed various technological recipes for ceramic masses, which have long been a secret for Galician companies, created a number of original colored ceramic paints, glazes, enamels (Shmahalo, 2005, p. 171). Important in the activities of the Station was that students and listeners of Lviv Polytechnic had the opportunity to study here directly, on specific examples.

One of the greatest achievements of the research team under the leadership of E. Krzhen was the invention of white glaze, products from which provided a competitive advantage for Galician art of creating tiles over products of foreign companies that produced white porcelain kilns. A valuable achievement of the Station was the invention and use of glazes and paints, which, after baking, produced specific effects characteristic of Japanese ceramics. Such glazes are widely used in many Western Ukrainian enterprises, in particular, in the decoration of vases, glasses, ceramic tiles. The technology of counterfeiting the "Japanese glaze" was so high quality that only the hallmark of the Galician company testified to the truth of the product (Shmahalo, 1999, p. 152). The Lviv Station played a significant role in the life of the Galician clay industry, the formation of the main centers of art-and-industrial production and education.

Note, however, that in the postwar years 1914–1920, the production of ceramics in Halychyna is in decline. It was only in the 1930s that attempts were made to restore it in Lviv. A porcelain workshop appears. In these years, sculptor S. Lytvynenko founded the sculpture and ceramic workshop "Eye" (Shmahalo, 2005, p. 175). In its place, already under Soviet rule, in 1946, the Lviv Experimental Ceramic and Sculpture Factory was opened. Since 1949, a specialized ceramic shop has been operating here. Since 1956, the Lviv Ceramic Plant of the Republican Production Association "Ukrbudkeramika" begins to produce products, where, along with construction and sanitary ceramics, artists work on the manufacture of souvenirs, as well as perform monumental and decorative compositions for the architectural environment. These enterprises have become the main base for the development of professional ceramics. However, there was an obvious need for specialists of the appropriate level.

Since 1946, the Lviv State Institute of Applied and Decorative Arts (now the Lviv National Academy of Arts) has been training highly qualified specialists. It is the only educational art institution of this kind in Ukraine. Since its inception, a specialized Department of Art Ceramics has been established. Moreover, Lviv School of Applied Arts (which will later be named after I. Trush) will start operating in Lviv on the site of the former Art-and-Industrial School. Since its opening, the methodology and quality of training of masters of art ceramics have been constantly improved. Subsequent achievements of Lviv professional decorative ceramics were the result of creative work of several generations of students of the local art school – graduates of these educational institutions.

Conclusions.

The art features of Halychyna ceramics were formed in the context of Western Ukrainian and European art of the 19th – first half of the 20th century. At the beginning of the 20th century in art-and-industrial ceramics, stylistic signs of modern, which received a fairly wide range of local names: "Rus' style", "East-Galician style", "Kolomyia style", "Hutsul secession", were clearly identified. Ultimately, the

most famous name is "Ukrainian modern", which brings out expressive counterparts in Eastern Ukraine. One of the main features of the Galician art-and-industrial ceramics of this time is the active involvement of folk traditions as a source of creative inspiration for the art of professional artists. In art-and-industrial ceramics of Halychyna, along with the eclectic manifestations, the local style of ceramics, which has gained recognition in Europe, has been formed.

At the turn of the 19th and 20th centuries in Halychyna, a corresponding infrastructure in the field of art-and-industrial ceramics, which covered educational institutions of lower, secondary, and higher qualifications; technical and technological services, small workshops, and large enterprises, highly qualified specialists – technologists and artists, was formed.

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Кераміка Галичини наприкінці XIX - початку XX століття. Наукові та професійні школи. Технології. Персоналії.

Анотація. *Аналіз числених пам'яток першої третини XX століття дає підстави стверджувати, що на Галичині розвивалося виробництво багатьох різновидів художньо-промислової кераміки, зокрема, архітектурної керамічної пластики, різноманітних виробів ужиткової кераміки, декоративної дахівки, кахлів, облицювальної плитки тощо. Мистецькі особливості художньої кераміки Галичини, багатство способів її декорування та формотворення, стилістичні особливості, а також численні мистецькі товариства, наукові та професійні об'єднання, групи, заводи та фабрики, які спеціалізувалися на виготовленні кераміки, відображають загальний розвиток цієї галузі в першій половині XX століття та становлять передумови виникнення школи професійної кераміки у Галичині на початку XX століття. Метою статті є аналіз становлення та розвитку наукових та професійних шкіл художньо-промислової кераміки Галичини в кінці XIX - початку XX століття. Методика дослідження була обрана відповідно до конкретного фактологічного матеріалу, поставлених у роботі мети й завдань, розгорталася на основі системного підходу й принципу історизму, із застосуванням методу комплексного мистецтвознавчого аналізу, який синтезує дослідницькі*

можливості порівняльно-історичного, функціонального, типологічного методів дослідження. Використовуваний принцип системності передбачав розгляд певних питань відповідно до послідовності процесів, які відбувалися в такому популярному різновиді професійного декоративно-ужиткового мистецтва як художня кераміка. Завдяки такому підходові автори намагалися зосередити увагу на докладному з'ясуванні шляхів формування професійної творчості в нерозривному зв'язку із врахуванням особливостей певного матеріалу, потребами відповідного матеріального забезпечення та налагодження технологічних процесів. Крім того, такий виклад матеріалу статті забезпечив чіткіше окреслення можливостей і перспектив розвитку мистецтва художньої кераміки. У процесі роботи автори усвідомлювали, що всі проблеми, які стосуються мистецтва першої половини ХХ століття, у тому числі й розвитку у виробництві художньої кераміки на Галиччині, перебувають лише на певній стадії ґрунтовного вивчення. Саме тому дана робота є лише одним з етапів на цьому шляху. У зв'язку з цим, дане дослідження трактувалося авторами не як таке, що має остаточно вичерпати обрану тему, а навпаки – робота має створити можливість наступного детальнішого вивчення окремих явищ, творчого доробку художників чи аналізу груп конкретних мистецьких творів.

Ключові слова: *декоративно-ужиткове мистецтво; художньо-промислова кераміка; технології виготовлення; особливості; український стиль; музеї Львова*

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Керамика Галичины в конце XIX - начале XX века. Научные и профессиональные школы. Технологии. Персоналии.

Аннотация. *Анализ многочисленных достопремичательностей первой трети XX века дает основания утверждать, что в Галичине развивалось производство многих разновидностей художественно-промышленной керамики, в частности, архитектурной керамической пластики, разнообразных изделий керамики, декоративной крыши, изразцов, облицовочной плитки и т.д. Художественные особенности художественной*

керамики Галичины, богатство способов ее декорирования и формообразования, стилистические особенности, а также многочисленные художественные общества, научные и профессиональные объединения, группы, заводы и фабрики, специализировавшиеся на изготовлении керамики, отражают общее развитие этой отрасли в первой половине Х столетия и составляют предпосылки возникновения школы профессиональной керамики в Галичине в начале ХХ века. Целью статьи является анализ становления и развития научных и профессиональных школ художественно-промышленной керамики Галичины в конце XIX – начале ХХ века. Методика исследования была выбрана в соответствии с конкретным фактологическим материалом, поставленным в работе цели и задачам, развертывалась на основе системного подхода и принципа историзма, с применением метода комплексного искусствоведческого анализа, синтезирующего исследовательские возможности сравнительно-исторического, функционального, типологического методов исследования. Используемый принцип системности предполагал рассмотрение определенных вопросов в соответствии с последовательностью процессов, происходивших в такой популярной разновидности профессионального декоративно-прикладного искусства как художественная керамика. Благодаря такому подходу, авторы пытались сосредоточить внимание на подробном выяснении путей формирования профессионального творчества в неразрывной связи с учетом особенностей определенного материала, потребностями соответствующего материального обеспечения и налаживания технологических процессов. Кроме того, такое изложение материала статьи обеспечило более четкое обозначение возможностей и перспектив развития искусства художественной керамики. В процессе работы авторы отдавали себе отчет, что все проблемы, касающиеся искусства первой половины ХХ века, в том числе и развития в производстве художественной керамики в Галичине, находятся только на определенной стадии основательного изучения. Именно поэтому данная работа является одним из этапов на этом пути. В связи с этим, данное исследование трактовалось авторами не как имеющее окончательно исчерпать избранную тему, а наоборот – работа должна создать возможность дальнейшего более детального изучения отдельных явлений, творчества художников или анализа групп конкретных художественных произведений.

Ключевые слова: *декоративно-прикладное искусство; художественно-промышленная керамика; технологии изготовления; особенности; украинский стиль; музеи Львова*

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MAN trolleybuses in Ukraine (1939–1951): a history, technical characteristics, features of operation

Abstract. *The growth of the vehicle assets and bus services in Ukrainian cities increases the level of environmental pollution. During the environmental crisis, electric transport (e-transport) is becoming a matter for scientific inquiry, a subject of discussion in politics and among public figures. In the program for developing the municipal services of Ukraine, priorities are given to the development of the infrastructure of ecological transport: trolleybuses, electric buses, electric cars. The increased attention to e-transport on the part of the scientific community, politicians, and the public actualizes the study of its history, development, features of operation, etc. The historiographic analysis carried out by the authors allows us to say about insufficient coverage by Ukrainian researchers of a number of aspects and periods in the history of e-transport. A small number of special works on the history of the operation of foreign-made trolleybuses in Ukrainian cities in the first half of the 20th*

century and an analysis of their technical characteristics determine the relevance and scientific novelty of this study. When writing the work, Ukrainian and foreign scientific reference publications, monographs, papers, mainly from foreign electronic resources, have been used. The authors have used both general scientific (analysis, synthesis, deduction, induction) and historical research methods, in particular, problem-chronological, comparative-historical, retrospective methods, etc. The aim of the study is to highlight little-known facts of the history of production and operation of MAN trolleybuses in Ukrainian cities, as well as to introduce their technical characteristics into scientific circulation. The etymology of the model names of German trolleybuses, which usually consisted of the names of the manufacturers of chassis, body, and electrical equipment, has been clarified. The types, specific design solutions of the first MAN trolleybus generation and the prerequisites for their appearance in Chernivtsi have been determined. Particular attention has been paid to trolleybuses that were in operation in Germany and other Western European countries from the first half of the 1930s to the early 1950s. In the mid-1930s, the MAN plant in Nuremberg began production of trolleybuses; its models had the most modern constructive solutions at that time, a characteristic design and a state-of-the-art heating system. Depending on the length, German manufacturers divided the trolleybus models into four types. As a result of problems with the operation of the bus fleet in Chernivtsi, the city authorities have decided to build a trolleybus line in the city; four trolleybuses manufactured by the MAN plant were purchased. The paper traces the stages of operation of the MAN trolleybuses in Chernivtsi, where they worked during 1939–1944 and after the end of the Second World War, they were transferred to Kyiv. After two years of operation in the Ukrainian capital, the trolleybuses entered the routes in Dnipropetrovsk during 1947–1951. The technical characteristics of the first MAN trolleybus generation, which were operated in Ukrainian cities, have been presented and analyzed. It was determined that in all the main indicators and operational parameters, they were as close as possible to similar models of German trolleybuses. The proposed methodology and the structure of the study can later be used to write papers on the history of science and technology, in particular, of an e-transport.

Keywords: *electric transport; trolleybus; operation; machine; Chernivtsi; Germany*

Introduction.

Public transport and municipal transport-and-road infrastructure play an extremely important role in the development of modern cities. Public transport significantly improves the quality of life in urban agglomerations, provides reliable, efficient, and cost-effective passenger service. It serves the interests of both individual citizens and the entire population of the city, expands individual opportunities and provides personal mobility.

In the context of the environmental crisis accompanied by the deterioration of the health of the world's population, the priority direction of the UN Environment Program is the development of an environmentally friendly transport. The critical state of the technological infrastructure in Ukraine threatens the socioeconomic development of the State, deepens environmental problems, and creates a negative image in the eyes of Western investors. In order to improve the situation under the National Transport Strategy by 2030, Ukraine plans to completely replace all urban public transport with an electric one and to create the appropriate infrastructure for this. So, in November 2020, V. Kryklii, Minister of Infrastructure, stressed that the government will continue to support the use of ecological modes of transport in cities, in particular an urban electric one and electric cars (Kabmin planuie..., 2020).

As of 2021, 42 trolleybus systems, by the number of which the State ranks second in the world, operate in Ukraine. The environmental friendliness and economy of this type of transport make it attractive for the transformation of an urban transport infrastructure. At the same time, problems that hinder the intensive development of trolleybus services are the obsolescence of rolling stock in most Ukrainian cities and competition with trams and subway in metropolises. In this regard, the study of the history of the trolleybus transport functioning in the cities of Ukraine and the technical features of its individual models is an urgent scientific problem.

Analysis of the latest research, which laid the foundation for solving the problem.

Modern historiography of e-transport can be divided into such components as studios on the general and Ukrainian history of e-transport, regional and local studies, in particular "Istoriia lvivskoho tramvaia" (Tarkhov, 1994), "Istoriia miskelektrotransportu Chernivtsiv" (Tarkhov, 1997a), "Pervyj v Krymu: Istoriya tramvaya i trolleybusa v Sevastopole" (Tarkhov, 1998), "Kyivskyi troleibus" (Kozlov & Mashkevych, 2009), etc. In addition to historical and regional studies, the problem of e-transport is present in works on economics, municipal management, papers in technical sciences, etc.

Among the editions of an encyclopedic nature, the encyclopedic guide, which became the first comprehensive study of the history of urban electric transport – a tram, a trolleybus, a subway, a funicular railroad – for the entire period of its existence in the cities of Ukraine, deserves attention (Tarkhov, Kozlov, & Olander, 2010). We should also mention the encyclopedia on the history of the trolleybus system in Germany – the trilogy "Obusse in Deutschland" (Kenning & Schindler, 2009), the materials of which were used in writing the work.

Ukrainian scientists S. S. Hutyria, D. M. Bordeniuk, and A. M. Chanchyn (2011) investigated and analyzed the technical evolution of trolleybuses produced by leading world and Ukrainian companies, identified trends in their technical level.

Much of the research at the local level is devoted to the history of the Kyiv trolleybus network, which became the first in the Ukrainian SSR. In particular,

K. Kozlov and S. Mashkevych (2009) highlighted the history of the development of the trolleybus facilities in Kyiv, revealed the features of the creation and development of the trolleybus network, traced the evolution of the types of trolleybuses that in different years run the streets of the capital of Ukraine. On the 75th anniversary of the launch of the trolleybus network, K. A. Bramskyi (2011, pp. 64–69) published a paper on the formation and development of the trolleybus network in Kyiv.

I. V. Kryvoviaziuk and S. O. Kraichuk (2016) analyzed the dynamics and structure of the sectoral passenger turnover in Ukraine, revealed the factors influencing the dynamics of the market situation in the bus and trolleybus construction market, characterized the bus and trolleybus construction market in Ukraine, identified the features of its functioning and further development.

Prospects and directions of development of the urban e-transport market in Ukraine, the state of its rolling stock was studied by O. M. Polinkevych (2019, pp. 120–124). The researcher identified the main manufacturers of e-transport in Ukraine, proposed the formation of a single carrier along urban routes, and substantiated the need to search for investments in order to finance programs for the development of e-transport in the context of a "smart city".

However, to date, no special studies on the history of operation of foreign-made trolleybuses in Ukraine with a description of their technical characteristics have been revealed.

For seventy years, more than twenty models of rolling stock of Ukrainian (for example, MTBES trolleybuses, various models of Kyiv and LAZ, machines of the Production Association Yuzhny Mashinbuilding Plant named after A. M. Makarov, State Enterprise, nowadays also Bogdan and Etalon), Russian (for example, MTB-82, ZiU trolleybuses), as well as foreign production (mainly Škoda trolleybuses) were in operation of the trolleybus facilities of Ukraine, in some cities, in particular Kharkiv – Rocar DAC). It should be noted that the MAN MPE I/MAN model went almost unnoticed. These are trolleybuses produced by the German machine-building enterprise Maschinenfabrik Augsburg & Nürnberg (MAN) in a small series of four cars, which became famous due to their operation in the cities of modern Ukraine—Chernivtsi, Kyiv, and Dnipro. All four vehicles were manufactured in the spring-autumn of 1938. Until the mid-2010s, these were the only MAN trolleybuses operating in Ukrainian cities. At the beginning of winter 2015, 29-year-old MAN SL 172 HO M12 vehicles were brought to Mariupol from Solingen (Germany).

For a long time, these trolleybuses remained one of the least known models of rolling stock operating on the roads of Ukraine, mainly due to a critical lack of information about their components and design features. Due to the efforts of historians, transport workers, and enthusiasts who have found their reflection in works such as "Kyivskyi troleibus" (Kozlov & Mashkevych, 2009), the history of these trolleybuses has been partially investigated, but information about the features of the MAN models is still lacking, and all technical details contain only specialized foreign literature.

The goal and objectives of the study.

The goal of the study is to highlight little-known facts of the history of production and operation of MAN trolleybuses in Ukrainian cities, as well as to introduce their technical characteristics into scientific circulation.

Achieving this goal requires solving the following research tasks:

– to find out the etymology of the model names of German trolleybuses;

– to determine the types, specific design solutions of the first MAN trolleybus generation and the prerequisites for their appearance in Chernivtsi;

– to trace the stages of operation of MAN trolleybuses in Chernivtsi, Kyiv, and Dnipropetrovsk during 1939–1951;

– to analyze the technical characteristics of the first MAN trolleybus generation, which were operated in Ukrainian cities.

Results and discussion.

Models of the rolling stock traditionally contain the name of the manufacturing plant (for example, Neoplan, Ikarus, LAZ, etc.), a specialized code (for example, MTB – for the Tushino Machine-Building Plant, AKSM – for the Belkommunmash Plant), or a numerical designation (for example, Kyiv-6, Škoda 8Tr, Henschel HS 6500). Many trolleybus models of German manufacturers had a similar designation; however, small-scale models were often not assigned numerical indexes or they were lost over time, and only the chassis index remained known. In this case, the name of the trolleybus consisted of three parts: 1) the name of the chassis manufacturer and its index, if it existed; 2) the name of the body manufacturer; 3) the name of the electrical equipment manufacturer.

This scheme is explained by the fact that, firstly, a trolleybus chassis was produced in Germany, which, in addition to the supporting frame, included a complete transmission, a suspension, axles, a braking system, a steering, a compressor with receivers and a drive motor for it; the set also, as a rule, included traction motors and a dynamotor (dynamo) (Figure 1).

Most of the trolleybus chassis was equipped with a massive fixing rack for the trailer (due to the insufficient passenger capacity of small-sized trolleybuses, many cities in Germany tested their operation with trailers), which was attached to the supporting frame in the rear overhang. The MAN and Henschel trolleybuses of the 1930–1940s had a similar chassis layout (Kenning & Schindler, 2009, p. 10; Kiebler, 2000). Secondly, such a chassis could be adapted to the body of another manufacturer, which became widespread in Germany. Trolleybus bodies were manufactured by more than 15 companies, in particular Schumann (Werdau), Bussing, Vetter (Fellbach), Kassbohrer (modern Setra), Rathgeber, etc. A similar situation has developed with electrical equipment mounted at the request of the customer. It should be noted that the trolleybus facilities in Germany used electronic equipment of such brands as Brown, Boveri & Cie, Siemens-Schuckertwerke, AEG, later – Secheron, Vossloh.

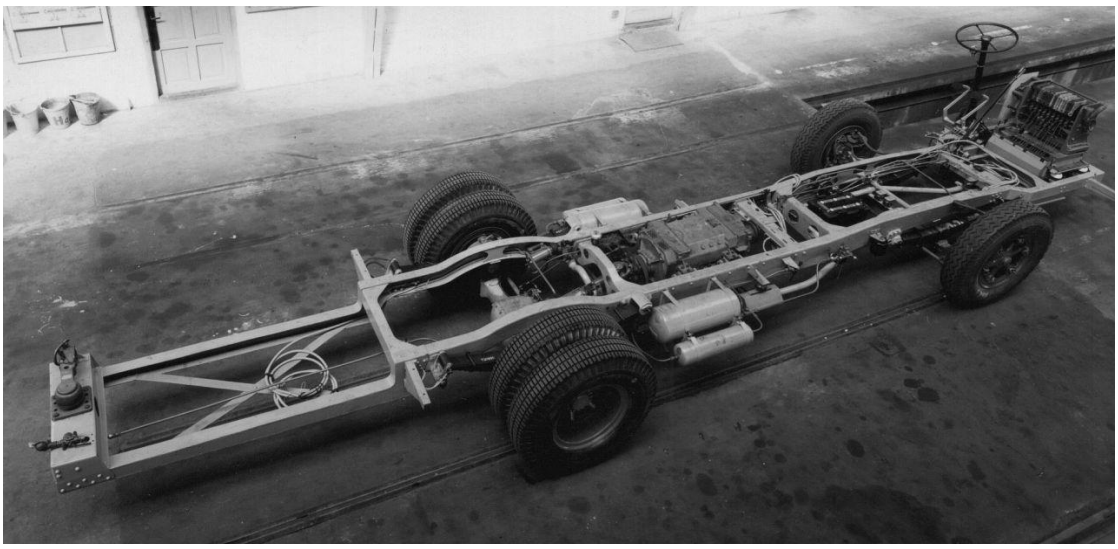

Figure 1. MAN MPE I standard trolleybus chassis, the 1940s model. The wheelbase is 4.25m, which is 1m less than in the early cars of the 1938 model. Also, early trolleybuses (Chernivtsi, Zwickau) had a rear axle single-tire wheel (in the photo – a classic double-tire wheel) (Kiebler, Ronald, 2000a).

Consequently, the name of the trolleybus consisted of three parts, which was often reflected in the technical documentation, even if there was a more accurate designation of the model (Kenning & Schindler, 2009, pp. 43–45).

As for the MAN trolleybuses, the manufacturing plant did not assign them an official numerical index, so there is no established name for the vehicles in the documented sources. Thus, such researchers as S. Tarkhov, K. Kozlov, and A. Olander (2010, pp. 156–157) operate with the word "trolleybuses", noting only manufacturers of bodies, assemblies, and electrical equipment. K. Kozlov and S. Mashkevych (2009) use the names "MAN-SSW" and "MAN-BBC". However, in view of the data contained in the Obusse in Deutschland, it can be argued that the trolleybus from Zwickau had the same chassis, called "MAN MPE I" (we are talking about its early version, since the wheelbase was one meter longer than its classic version) (Kenning & Schindler, 2009, pp. 208–209). So, in our opinion, it is advisable to call it MAN MPE I/MAN/BBC, MAN MPE I/MAN/SSW.

It is also possible to suggest that the names of trolleybuses with similar body, chassis, and electrical equipment manufacturers and without existing numerical indexes should be supplemented with the designation of the city, in which the trolleybuses were operated, such as MAN MPE I/Schumann/BBC (Zwickau). It should be noted that, according to German standards, Chernivtsi trolleybuses belong to dimension I.

History of appearance, production, and operation. The positive experience of operating the first-generation trolleybuses in the early and mid-1930s aroused significant interest among automobile operating companies in Europe. It is worth

recalling that the trolleybus motor, unlike the bus diesel one, did not pollute the atmosphere and did not need a gearbox. Moreover, according to statistics, trolleybuses had a significantly longer amortization period (approximately 12–15 years (Tarkhov, Kozlov, & Olander, 2010, p. 151)), according to other data that related to German-made trolleybuses, incl. "MAN", – 20-30 years (Lochte et al., 1991, pp. 394–399).

The MAN plant in Nuremberg, like several other German engineering companies, attempted to produce electric vehicles, producing a series of four trolleybuses in 1934–1935. Three-axle trolleybuses with a box-shaped body shape characteristic of that time were named MAN 8E2 after the chassis index and the nickname "Elbus" (Kenning & Schindler, 2009, pp. 43–45). The design solutions embodied in these vehicles, in particular the motor-in-wheel, porcelain insulating materials for electrical equipment and the water boiler heating system, were progressive, although the bow heads remained roller ones (Jurziczek, 2004). In addition, the MAN 8E2 transmission included two Siemens DG344A single-commutator motors with a capacity of 44 kW·h (Kenning & Schindler, 2009) (according to other sources, Siemens DW 602A with a capacity of 45kWh) (Jurziczek, 2004)), which were fixed on the side members of the bearing frame from the outside and transmitted the torque directly to each traction wheel (a middle pair) through differentials with a conical final drive. Thus, the trolleybus did not have a classic axle.

One of these trolleybuses was presented at the Internationalen Automobilausstellung – 1935 Exhibition (Frankfurt am Main). Such vehicles have been in service on German roads for over 20 years. So, the first attempt to produce electric vehicles for the MAN plant was successful.

At the beginning of 1937, the magazine "Verkehrstechnik" proposed to use a parameter called Normgröße (in English "normalized size"), which consisted in the need to systematize the dimensions of trolleybuses, according to 4 types of dimensions:

I – length up to 9 m (according to other sources, up to 10 m);

II – length from 9 m to 10 m;

III – length from 10 m to 11 m;

IV – length from 11 m to 12 m (at that time – three-axle vehicles) (Kenning & Schindler, 2009, pp. 10–11).

It should be added that in the 1950s, the Austrian Graf & Stift company supplemented this classification by including the V, VI, and VII types of dimensions to designate their articulated vehicles, but such designations were not widely used.

Note that these designations are rather arbitrary. They might not coincide with the real length of the trolleybus, however, for differentiation of vehicles with a length of 8.6 m and 10.1 m (the dimensions of the Henschel machine-building enterprise – I and II) were considered quite satisfactory (Kozlov & Mashkevych, 2009, p. 484). It should be borne in mind that it is difficult to determine the standardized size if the vehicle body

length is, for example, 9m, as in the MAN MPE 4500 with the Schumann Werdau body. In this case, the manufacturer's designation should be followed.

The need to standardize trolleybuses was considered by the German Commercial Vehicle Manufacturers' Union (Verband deutscher Kraftverkehrgesellschaft) in Dortmund. The result of the meeting was the Order dated September 9, 1937, for the enterprises: Daimler-Benz, Kassbohrer, Schumann, DUWAG, AEG, BBC, and SSW to develop a concept. In March 1938, the Union drew up plans for the production of Type I and Type II vehicles (Kenning & Schindler, 2009, pp. 10–11). Considering the above, we can conclude that the Chernivtsi MAN vehicle belongs to type I dimensions, since its body length is 8.7 m (Kozlov & Mashkevych, 2009, p. 484).

At the beginning of 1937, due to the ineffective operation of buses, the Bukovyna Joint Regional Transport Company (BJRTC), which included the tramway facilities of Chernivtsi, began to study the experience of European countries in the use of trolleybuses. Inquiries on this issue were sent to a number of European countries. Positive foreign experience has contributed to the rapid introduction of the trolleybus service in Chernivtsi (Tarkhov, 1997b, pp. 23–24). The auction for the purchase of trolleybuses was held on April 22, 1937. BJRTC has decided to buy vehicles abroad. Initially, it was planned to purchase five trolleybuses, but the mayor's office has allocated 6 million lei for the purchase of only four units. It should be added that the costs of building a trolleybus facility in the city totaled 12.4 million lei (Tarkhov, 1997, p. 23; Tarhov, Kozlov, & Olander, 2010, p. 152). According to German prices, one MAN trolleybus of this model cost 38,300 Reichsmarks (Tarkhov, Kozlov, & Olander, 2010, p. 152).

It is difficult to name the foundations of BJRTC for ordering small-batch trolleybuses with electrical equipment from two different manufacturers, the operating experience of which did not go beyond Germany, Austria, and Switzerland by the end of the 1930s. Moreover, Ukrainian sources contain some inaccuracies. So, some of them provide information that trolleybuses were manufactured in Augsburg (Tarkhov, 1997, pp. 23–24; Kozlov & Mashkevych, 2009, pp. 54–58), while others indicate the Nuremberg plant (Lochte et al., 1991, pp. 394–402). According to the MAN commercial vehicle guide, the first-generation trolleybuses were manufactured only at the plant in Nuremberg (Kenning & Schindler, 2009, p. 46), which contradicts the data of Ukrainian sources.

It cannot be argued that these MAN trolleybuses (and not other MAN vehicles, which since 1938, there have been a large number) were ordered for the city of Chernivtsi (Tarkhov, Kozlov, & Olander, 2010, p. 156), as the trolleybuses mentioned above were originally intended for the Berliner Verkerhrsbetriebe transport company (BVG). They were assembled in the autumn of 1938, and one of them repeated the success of its predecessor (MAN 8E2), since the MAN trolleybus entered the exhibition for the second time. This time it was called Wagenschau Düsseldorf and took place on November 17–19, 1938. All modern models of transport were presented at the exhibition, including tramways and trolleybuses, in

particular a trolleybus with electrical equipment manufactured by SSW (Kenning & Schindler, 2009, p. 46). Another model of MAN trolleybuses also aroused interest among specialists (Tarkhov, 1997, p. 24; Tarkhov, Kozlov, & Olander, 2010, p. 156; Kenning & Schindler, 2009, pp. 42–46).

The exact date of manufacture of the vehicles has not been defined, although it is known that the assembly of trolleybus bodies began in the spring of 1938, and the assembly ended in November (Tarkhov, Kozlov, & Olander, 2010, p. 153). It is doubtful that MAN, with its significant production capacity, has been assembling for half a year. It can be assumed that the use of electrical equipment from two manufacturers on a small series of four trolleybuses is a consequence of the refusal of the BVG transport company from such vehicles. It cannot be ruled out that existing electrical equipment was installed on them.

The transportation of MAN trolleybuses to Chernivtsi was carried out by Compas, the Romanian company, together with the German West & Bachmayer (with a representative office in Bucharest). The first two trolleybuses arrived on January 11, 1939, the last two – on January 14 (Tarkhov, Kozlov, & Olander, 2010, p. 153; Tarkhov, 1997, p. 24). The newspaper "Glasul Bukovinei" highlighted the arrival of electric transport in Chernivtsi and called the trolleybuses very comfortable. The first test drive took place on the night of January 12–13 and on January 21 at 22:00 all four MAN trolleybuses went for a run-in. The trolleybus service opened on February 1, 1939, three trolleybuses operated on the line, the fourth vehicle remained in reserve. Trolleybuses received inventory numbers 1–4 (Tarkhov, Kozlov, & Olander, 2010, p. 153–156; Kozlov & Mashkevych, 2009, p. 56). The MAN trolleybus with inventory number 3 is shown in Figure 2.

Figure 2. The MAN trolleybus with inventory number 3 in Chernivtsi in 1939 (Gorodskoj elektrotransport, 2002–2021b).

In June 1940, the city of Chernivtsi was joined to the Ukrainian SSR, after which the Soviet YaTB-4 began operating along with the MAN trolleybuses. Certainly, imported trolleybuses with an all-metal welded body and more powerful traction electric motors (TEMs) were more up-to-date in nature, but in other respects (air-brake systems, sliding heads of bow), they were similar.

MAN trolleybuses operated in Chernivtsi until March 1944. The Army of the Third Reich, retreating, evacuated all rolling stock deep into Romania – the trolleybuses ended up at the Astra Brasov Automobile Plant (Kozlov & Mashkevych, 2009, pp. 56–57). According to some indications, the plant came under rocket bombardment, but the trolleybuses remained unharmed.

In the spring of 1945, after the resumption of the movement of electric transport in Kyiv, the MAN trolleybuses were taken from Brașov to Kyiv. The Kyiv trolleybus facilities experienced a shortage of rolling stock, since the weak repair base did not ensure timely restoration. In the 1940s, mostly pre-war YaTB-1 trolleybuses remained in operation, for which there were not enough spare parts and assemblies (Kozlov & Mashkevych, 2009, pp. 56–57). The operation has made adjustments: some units were replaced with Ukrainian counterparts, and plush seats in the passenger compartment were replaced with simple wooden benches (Kozlov & Mashkevych, 2009, pp. 56–57). It should be noted that German public transport manufacturers even installed plush or leatherette seats on vehicles of the 1930s. A complete set of MAN MPE (I) 4500 “luxury” trolleybuses in Salzburg in 1940 provided for soft seats. The benches were installed in the most difficult times (approximately 1942–1946) in a simplified design of KEO military-type trolleybuses to make the vehicles as cheap as possible. Most of them were made by the Henschel Machine-Building Enterprise (Kenning & Schindler, 2009).

At the end of 1947, it was decided to transfer all four MAN trolleybuses delivered to Kyiv free of charge to Dnipropetrovsk, where trolleybus service was opened in November (Kozlov, 2011). The trolleybuses were accompanied by Kyiv drivers, who briefed their Dnipropetrovsk colleagues for some time. The MAN vehicles opened the trolleybus service in Dnipropetrovsk on November 7, 1947 (Figure 3). They received inventory numbers 1–4 and operated until 1951 (Kozlov, 2011).

Technical description. The MAN MPE I/MAN/… trolleybus belongs to the models of Nuremberg trolleybuses manufactured on a special trolleybus chassis MPE I, which used unified units from different manufacturers. This design is based on a supporting frame, consisting of two side members and several crossbars, on which the body and all the necessary units are mounted. An early prototype of the MPE I trolleybus chassis was used by MAN trolleybuses in Zwickau (No. 21–22) (Kenning & Schindler, 2009, p. 208). Their main feature was single-rod current transfer through one massive two-pole rod as an experiment of the Brown, Boveri & Cie Plant (Kenning & Schindler, 2009, pp. 198–208; Společnost pro veřejnou dopravu, 2011). The wheelbase of the MAN MPE I chassis, as mentioned above, was 5.25 m (Drehscheibe Online...), while the classic chassis was 4.25 m, that is, one meter less

(Kiebler, 2000; Lochte et al., 1991, pp. 394–401). It was this chassis that the MAN MPE I 4500 series, known for its work in Esslingen (Kiebler, 2000), Eberswalde, and other cities of Germany, had. By the way, several 8.6-meter vehicles appeared even in Sofia (Bulgaria). They differed only in the body manufacturer, at the same time, the body length was 8.65–9.25 m (Drehscheibe Online...). These include the Bratislava vehicle MAN MPE I/Sodomka/Siemens, which is very similar in body layout to the trolleybus in Zwickau (with a single door for entry and exit with a width of 1.15 m) (Kenning & Schindler, 2009, pp. 208; Popis typu vozidla…, n. d.). The body frame, mounted on the frame, consisted of rectangular tubes made of nickel-plated steel. This material ensured the proper rigidity of the structure and a relatively light container – the trolleybus curb weight was only 8.5 tons (Tarkhov, 1997, pp. 23–24). The cladding consisted of solid-drawn steel sheets welded to the frame.

Figure 3. The MAN MPE I/MAN/BBC trolleybus opens trolleybus service in Dnipropetrovsk on November 7, 1947 (Kozlov, 2011).

Since 1938, the MAN plant in Nuremberg has been producing trolleybus chassis on which bodies from different manufacturers could be mounted. In Esslingen, trolleybuses on the MAN MPE I 4500 chassis were operating with bodies from three different manufacturers: Schumann Werdau GmbH, Kassbohrer Ulm (modern bus manufacturer Setra), and Vetter Fellbach (Kiebler, 2000). The resource of the body of these trolleybuses is not indicated in the sources, however, taking into account the documentation on the operation of similar models of trolleybuses, it can be argued

that with proper maintenance, the vehicles are capable of operating from 20 to 27–31 years.

MAN MPE I/MAN/… trolleybuses in Chernivtsi had a body length of only 8.7 m, which makes it possible to classify them as type I (Kozlov & Mashkevych, 2009, p. 484; Kenning & Schindler, 2009, p. 11). German manufacturers of trolleybus chassis and body shown a flexible approach, as 11-meter (and longer) trolleybuses were not in high demand on routes and in cities with low passenger traffic. Moreover, small-sized trolleybuses have shown themselves to be maneuverable on narrow streets, where large-scale equipment is not able to work. The MAN trolleybuses considered in the study are as close as possible to the MAN vehicles in Eberswalde (in appearance) and Zwickau (base – 5.25 m) (Drehscheibe Online…). MAN trolleybuses related to Chernivtsi models are shown in Figures 4–6.

Figure 4. MAN MPE I/Schumann/BBC trolleybus produced in 1938 with a single-rod current collector in Zwickau (the two-pole rod was later replaced by two conventional collectors) (Gorodskoj elektrotransport, 2002–2021a).

In those days, the box-shaped body of the trolleybus became widespread due to the relative ease of manufacture. The streamlined forms of the MAN vehicles from Zwickau really looked futuristic, but the Chernivtsi trolleybuses had a strict design, very close to their successors – the single-pole trolleybuses from Eberswalde. The half windshield was framed by thin aluminum profiles, the front end was tapered to a certain extent, starting from the front overhang, and the lighting technology is traditionally represented by single rounded headlights. The route indicator of the trolleybus had a peculiarity: the signs with the directions of movement could be

replaced at the final stop with a lever from the driver's cab using a tape (Tarkhov, Kozlov, & Olander, 2010, p. 157). The bumper with bottom-mounted "MAN." logo blocked access to the contactor panel, the air absorber of which is visible in the photographs (Figures 4–6), so it had to be removed to service the electrical equipment.

Figure 5. MAN MPE 4500 I/Sodomka/SSW trolleybus produced in 1940 with current collectors mounted on one axle in Bratislava (then Czechoslovakia) (Popis typu vozidla…, n. d.).

Figure 6. MAN MPE 4500 I/Kassbohrer/BBC trolleybus produced in 1944 with standard current collectors and camouflaged headlights in Esslingen (pictured late model on MAN MPE I chassis) (Kiebler, Ronald, 2000b).

The electrical equipment of Chernivtsi vehicles was produced by two firms – Siemens-Schuckertwerke and Brown, Boveri Cie (Tarkhov, Kozlov, & Olander, 2010, pp. 156–157). Traditionally, in the first generation of German trolleybuses (Kiebler, 2000), it was placed under the floor of the passenger compartment and mounted on a frame. The traction motor was located in the wheelbase closer to the rear axle. A two-commutator 90kWh motor was installed on trolleybuses with Siemens-Schuckertwerke electrical equipment (Kenning & Schindler, 2009, pp. 42–46) and with Brown, Boveri & Cie electrical equipment – 85kWh motor. The transmission included a cardan drive and a single-stage left-offset gearbox (differential) that transmitted torque to the rear traction wheels. Both driven and driving axles were manufactured by MAN. The sources do not contain information about the type of rear-axle drive and the gear ratio of the rear axle. It can be assumed that it was equal to 1:9.94, as in vehicles in Zwickau and Esslingen (Kiebler, 2000; Společnost pro veřejnou dopravu, 2011). It is impossible to determine the type of the main gear, since the MAN trolleybuses were equipped with different types of gears: for example, the MAN 8E2 vehicles were equipped with a conical rear-axle drive (Jurziczek, 2004), while the vehicles in Zwickau had a worm-gear (gear-screw) one (Společnost pro veřejnou dopravu, 2011), and later MKE series (1, 2, 3, 590 HEC I) had a conical one (M.A.N., 1956).

Chernivtsi vehicles had dependent spring suspension of driven and driving axles and diskless single wheels with tires measuring 12.00–20.00 (later the tire size on MAN trolleybuses became much smaller – 9.75 or 10.00–20.00) (Kenning & Schindler, 2009, p. 10; Lochte et al., 1991, pp. 397–399). MAN trolleybuses had tires of the Swiss production: GF, Trilex (Lochte et al., 1991, pp. 396–398). As for the type of braking system, since the vehicles in Zwickau had a two-circuit one, it can be assumed that there is a braking system of the same type for Chernivtsi trolleybuses.

Like other models of MAN vehicles, they were equipped with three types of brakes – electrodynamic, pneumatic, and parking. The advantage of the detail is the spare wheel, in the original version, placed on a stand, which was fixed on the rear panel. Spare wheels were provided for vehicles in Bratislava (Popis typu vozidla…, n. d.) and Zwickau (Kenning & Schindler, 2009, pp. 198–209). They are absent on trolleybuses of the MPE 4500 and MKE series. As the photos of Kyiv and Chernivtsi vehicles show, spare wheels were not transported on the rear panel.

The vehicles in Chernivtsi were equipped with standard slip collectors, in contrast to the MAN 8E2, where American-made Dickinson Electric roller heads were installed (Jurziczek, 2004). On the basis of the poles, special headlights were mounted for lighting at night, which German manufacturers had practiced before. The electrical kits, as indicated above, were mounted on a supporting frame.

MAN trolleybuses had a rheostatic-contactor control system (RCCS) of the traction motor, which was carried out in two versions. The first version from SSW was automatic. The switching of the groups of starting and brake rheostats was

carried out using a group rheostatic controller (GRC), the shaft of which was driven by a service electric motor powered by a high-voltage network (Kenning & Schindler, 2009, pp. 42–46). It should be noted that the servo motors from GRC in future generations of trolleybuses (for example, in the Soviet ZiU-5 trolleybus) were powered from a low-voltage network (12V or 24V). The clutch pins mounted on the electric motor, during the rotation of the GRC shaft, closed and opened the contacts, sequentially removing certain rheostats from the motor circuit, thereby increasing the TEM current. A drawing of the MAN MPE I/MAN/SSW trolleybus is shown in Figure 7.

This option was more expensive and less common than the manual option. The developer of the latter was the Brown, Boveri & Cie in 1930 (Electric drive…, 2008). The non-automatic RCCS was tested on two experimental trolleybuses, one of which was manufactured jointly by Daimler-Benz and the BBC and was used for 8 years on a special line in Mannheim and, from November 1938, it worked in Zwickau at No. 20. Its total service life was 29 years (Kenning & Schindler, 2009, pp. 208–209). There is no data on the second vehicle.

The non-automatic version of the RCCS by BBC provided for the actuation of the driver controller from the accelerator pedal or the brake pedal (Kiebler, 2000), which closed the contact clutch pins with the help of rods, accordingly, the contactor coil circuit was closed, and it, magnetizing, pulled the movable contact, which removed the rheostats from the traction motor circuit (Kiebler, 2000; Popis typu vozidla…, n. d.). A non-automatic RCCS was installed on most German trolleybus models; it was discontinued in the mid to late 1950s. Low-voltage electricity consumers, in particular passenger compartment lighting, sound signals, trolleybus dashboard equipment, were powered by a generator (a dynamotor) and, in case of current collectors falling from the contact network or no current in it – from one battery. Its exact characteristics have not been established, however, given the average performance of the MAN and Henschel trolleybuses, the capacity of such a battery should be approximately 0.7–1.2 kW·h and its capacity should be 150–162 A·h.

The generator was mounted on a base frame and powered by the TEM. The generator and the battery were manufactured by Bosch. The compressor, which ensured the functioning of the vehicle door opening mechanism and the operation of the braking system, was driven by a high-voltage electric motor and filled with compressed air two receivers with a capacity of 40 liters (Kiebler, 2000; Drehscheibe Online…).

The MAN MPE I/MAN/ trolleybuses had a doorway layout unusual for the first-generation German trolleybuses – in the front overhang and in the base. In 1940, their location changed, according to the principle: “front overhang – rear overhang” or “base (offset to the front axle) – rear overhang”. Certainly, there were vehicles with four-wing doors in the base, to which the MAN trolleybuses in Zwickau and Bratislava belonged (Kenning & Schindler, 2009, pp. 208–209; Popis typu vozidla…, n. d.), as well as an unusual design later model of the second half of the 1940s, the most common in Munich – Kraus-Maffei KME 130 (with the Rathgeber body, since

the Kassbohrer body assumed two doors located in the wheelbase). The following models, including one of the most common trolleybuses in Germany ÜHIIIs by Henschel & Uerdingen, had a classic three-door layout.

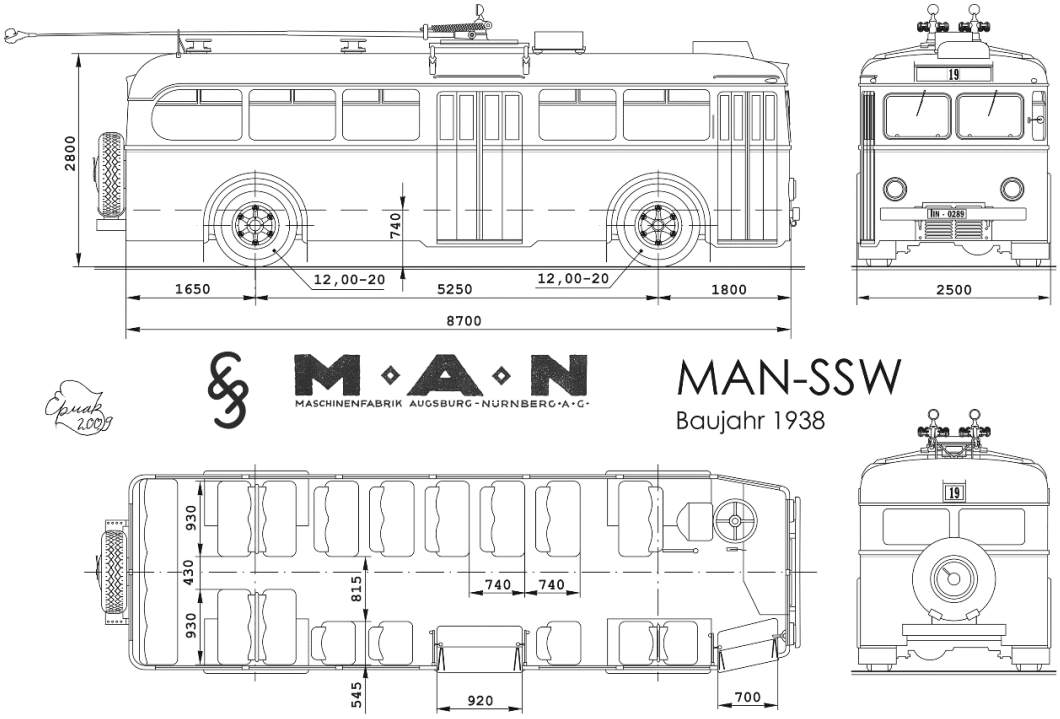

Figure 7. A drawing of the MAN MPE I/MAN/SSW trolleybus (Kozlov & Mashkevych, 2009).

In the original configuration, the MAN trolleybuses had 30 seats, the upholstery of which was made of plush (Tarkhov, Kozlov, & Olander, 2010, pp. 151–152), however, after refurbishment in Kyiv, they were replaced with simple wooden benches – eight doubles on the left side, two doubles in the rear overhang, and five single ones further. At the back was a five-seat sofa, also typical of vehicles in Zwickau. It should be noted that the layout of the trolleybus passenger compartment could differ significantly, depending on the customer's wishes. The windows provided two hinged vents for each one (for safety). The trolleybuses were not equipped with roof hatches (this type of ventilation was not widely used on German vehicles). Forced ventilation with electric fans was not provided, although a scrap from the newspaper "Glasul Bukovinei" dated January 12, 1939, given in the encyclopedic guide by S. Tarkhov, K. Kozlov, and A. Olander, convinces that "…the lighting is electric, and the ventilation is automatic…" (2010, p. 157). In our opinion, this is a technical mistake, since it is known that German manufacturers, including MAN, were already experimenting with forced ventilation. It could be tested at the presentation of the MAN MPE I 4500 with an improved configuration (with Schumann body and BBC electrical equipment) in Salzburg during the opening of the

trolleybus service in 1940. Heating of the passenger compartment in the cold season was carried out with the electric furnaces (Tarkhov, Kozlov, & Olander, 2010, p. 157). German-made vehicles were equipped with them by default, with the exception of the period for which manufacturers had to save on picking (approximately 1942–1946). In addition to Germany, simplified trolleybuses also operated in Gdynia (both German and local assembly – on the Henschel chassis with the body by the Gdansk Carriage Works).

Table 1 shows the technical characteristics of the MAN MPE I/MAN/SSW and MAN MPE I/MAN/BBC trolleybuses.

Table 1. Technical characteristics of MAN trolleybuses

Parameter	Value	Source or clarification
General information		
Chassis manufacturer	MAN (Nuremberg)	Tarkhov, Kozlov, & Olander, 2010, p. 157
Body manufacturer	MAN (Nuremberg)	Tarkhov, Kozlov, & Olander, 2010, p. 157
Electrical equipment manufacturer	Brown & Boveri, Cie, Siemens-Schuckertwerke	Tarkhov, Kozlov, & Olander, 2010, p. 157; Kenning & Schindler, 2009, pp. 42–43; Kozlov, 2011
Body		
Body	with frame base, welded, all-metal; frame sheathing and tubes are made of nickel-plated steel	Kozlov & Mashkevych, 2009, p. 56; Kiebler, 2000; Drehscheibe Online…
Chassis	MAN MPE I	documentation Kenning & Schindler, 2009; Büllov, 1997
Overall dimensions		
Body length, mm	8700	Kozlov & Mashkevych, 2009, p. 484; Kenning & Schindler, 2009, pp. 42–43
Width, mm	2500	Kozlov & Mashkevych, 2009, p. 484
Body height, mm	2800	Kozlov & Mashkevych, 2009, p. 484

Wheelbase, mm	5250	Kozlov & Mashkevych, 2009, p. 484
Front overhang, mm	1800	Kozlov & Mashkevych, 2009, p. 484
Rear overhang, mm	1650	Kozlov & Mashkevych, 2009, p. 484
Interior floor height above surface level, mm	740	Kozlov & Mashkevych, 2009, p. 484
Motor and electrical equipment		
Type	Siemens DV602a, four-pole, two-commutator, series-wound BBC GLM 1273 DK, four-pole, two-commutator, series-wound	Kenning & Schindler, 2009, pp. 42–46; Společnost pro veřejnou dopravu, 2011
Power, kWh	90 85	Kenning & Schindler, 2009, pp. 42–46; Společnost pro veřejnou dopravu, 2011
Nominal armature speed, rpm	1500	Kenning & Schindler, 2009, pp. 42–47
Voltage of high-voltage electrical equipment, V	550	documentation
Voltage of low-voltage electrical equipment, V	12	documentation
TEM management	rheostatic-contactor automatic (SSW) non-automatic (BBC)	Kozlov & Mashkevych, 2009, p. 484
TEM placement	wheelbase (moderately offset to the rear axle)	documentation
Low voltage electrical equipment manufacturer	Bosch	documentation

Transmission and braking system		
Gear system	single-stage, with differential offset on the port side	Tarkhov, Kozlov, & Olander, 2010, p. 157
Drive axle	MAN (rear axle)	Kiebler, 2000
Rear-axle ratio	1:9.94	Kiebler, 2000
Rear-axle drive	tapered or worm-gear (it is not precisely established by sources and documentation)	Drehscheibe Online…; Společnost pro veřejnou dopravu, 2011; M.A.N., 1956; Kenning & Schindler, 2009, pp. 42–46
Braking system	pneumatic double-circuit	Kenning & Schindler, 2009, p. 208–209
Dynamo	Bosch	documentation
Compressor unit	Bosch	documentation
Passenger compartment		
Number of doors for passengers	2	Kenning & Schindler, 2009, pp. 42–47; Kozlov & Mashkevych, 2009, p. 484
Doors, type	four-wing, platen-type, with pneumatic opening mechanism	Kozlov & Mashkevych, 2009, p. 484
Front door width, mm	700	Kozlov & Mashkevych, 2009, p. 484
Second door width, mm	920	Kozlov & Mashkevych, 2009, p. 484
Single seat width, mm	545	Kozlov & Mashkevych, 2009, p. 484
Double seat width, mm	930	Kozlov & Mashkevych, 2009, p. 484
Seat clearance, mm	740	Kozlov & Mashkevych, 2009, p. 484
Aisle width between rows, mm	815 430 (rear verhang)	Kozlov & Mashkevych, 2009, p. 484

Number of seats in the passenger compartment, pcs.	30	Kozlov & Mashkevych, 2009, p. 56
Total capacity, pass.	50	Kozlov & Mashkevych, 2009, p. 56
Additional information		
Tire size	12.00–20.00	Kozlov & Mashkevych, 2009, p. 484
Putting on a tire	single-tire (front axle) single-tire (rear axle)	Kozlov & Mashkevych, 2009, p. 56
Tire manufacturer	GF, Trilex (Switzerland)	Lochte et al., 1991, pp. 395–398
Maximum speed, km/h	58	Kenning & Schindler, 2009, pp. 42–46

Conclusions.

Urgent environmental problems of our time are increasingly forcing the governments of States, including Ukraine, to pay attention to the expansion of the infrastructure of e-transport. Its most developed component in Ukraine is trackless e-transport, the first trolleybus line of which celebrated its 85th anniversary in 2020. Despite the interest of researchers in the history of e-transport, its technical characteristics, and role in the socioeconomic development of local communities, many different aspects remain without their attention. One of the little-known pages in the history of e-transport in Ukraine is the operation of MAN trolleybuses in Chernivtsi, Kyiv, and Dnipropetrovsk during 1939–1951.

MAN trolleybuses have appeared on the roads of Ukraine in the mid-2010s after more than sixty-year hiatus. The Ukrainian and German practice of naming trolleybus models has common features: the name consists of the abbreviation of the manufacturing plant, to which a digital or alphabetic index is attached.

In the early 1930s, European motor transport concerns are interested in the production of trolleybuses, which had a number of advantages over buses: environmental friendliness, simpler transmission, and longer service life. It was the unsatisfactory condition of buses in the urban transport sector that forced the municipal authorities of Chernivtsi to introduce a trolleybus network. The opening of the trolleybus service on February 1, 1939, was an outstanding event in the life of Chernivtsi, which became the second Ukrainian city after Kyiv, where this type of transport began to be used. Operation of MAN trolleybuses in Chernivtsi has continued both after joining Bukovyna to the Ukrainian SSR and during the Second

World War until June 1944. In the postwar period, Chernivtsi MAN trolleybuses worked on the lines of Kyiv and in 1947–1951 – in Dnipropetrovsk.

In appearance, equipment, and technical characteristics, the MAN trolleybuses, which entered the line in Chernivtsi in 1939, can be attributed to the first generation of German trolleybuses. They did not differ much from similar models operating at that time in Germany or Poland, but they had more powerful electric motors and comfortable interiors than Soviet trolleybuses.

The existing source base did not allow to determine the exact dates of the vehicle production and the reasons for the purchase of this particular model of trolleybuses by the Chernivtsi municipality from the MAN Concern. Some of their technical characteristics also remain unclear. The attraction of new sources can reveal the above aspects and describe in more detail the period of operation of Chernivtsi trolleybuses in Kyiv and Dnipropetrovsk before their decommissioning in 1951. The characteristics of the MAN trolleybuses given in the work can be used both in historical works and in studies of a technical nature. In the future, the methodology and the structure of the research proposed by the authors can be used in the studying the history of e-transport at the local and regional levels.

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Тролейбуси "MAN" в Україні (1939-1951): історія, технічні характеристики, особливості експлуатації

Анотація. *Зростання автомобільного парку й автобусних перевезень у містах України підвищує рівень забрудненості навколишнього середовища. В умовах екологічної кризи електротранспорт стає об'єктом наукових досліджень, предметом дискусій у середовищі політиків і громадських діячів. У програмі розвитку муніципального господарства України пріоритети надано*

розбудові інфраструктури екологічного транспорту: тролейбусів, електробусів, електромобілів. Підвищена увага до електротранспорту з боку наукового співтовариства, політикуму та громадськості актуалізує дослідження його історії, розвитку, особливостей експлуатації тощо. Проведений авторами історіографічний аналіз дає підстави говорити про недостатнє висвітлення українськими дослідниками низки аспектів і періодів в історії електротранспорту. Незначна кількість спеціальних робіт з історії експлуатації тролейбусів іноземного виробництва в українських містах у першій половині ХХ ст. та аналізу їх технічних характеристик зумовлюють актуальність і наукову новизну цього дослідження. При написанні роботи були використані українські й зарубіжні науково-довідкові видання, монографії, статті, здебільшого із закордонних електронних ресурсів. Авторами були застосовані як загальнонаукові (аналіз, синтез, дедукція, індукція), так і власне історичні методи дослідження, зокрема проблемно-хронологічний, порівняльно-історичний, ретроспективний методи тощо. Метою дослідження є висвітлення маловідомих фактів з історії виробництва та експлуатації в українських містах тролейбусів "MAN", а також уведення до наукового обігу їх технічних характеристик. З'ясовано етимологію назв моделей німецьких тролейбусів, яка зазвичай складалася з назв заводів-виробників шасі, кузову й електрообладнання. Визначено типи, специфічні конструктивні рішення тролейбусів "MAN" першого покоління та передумови їх появи в Чернівцях. Особлива увага зосереджена на тролейбусах, які були в експлуатації в Німеччині та інших західноєвропейських країнах із першої половини 1930-х рр. і до початку 1950-х рр. У середині 1930-х рр. випуск тролейбусів розпочав завод "MAN" у Нюрнберзі, його моделі мали найсучасніші на той час конструктивні рішення, характерний дизайн і новітню систему опалення. Залежно від довжини німецькі виробники поділяли моделі тролейбусів на чотири типи. Внаслідок проблем із експлуатацією автобусного парку в Чернівцях міська влада прийняла рішення щодо побудови в місті тролейбусної лінії; було закуплено чотири тролейбуси виробництва заводу "MAN". У статті простежено етапи експлуатації тролейбусів "MAN" у Чернівцях, де вони працювали протягом 1939–1944 рр., а після закінчення Другої світової війни були переведені до Києва. Після дворічної експлуатації в столиці тролейбуси протягом 1947−1951 рр. виходили на маршрути в Дніпропетровську. Наведено й проаналізовано технічні характеристики тролейбусів "MAN" першого покоління, які експлуатувалися в українських містах. Визначено, що за всіма основними показниками й експлуатаційними параметрами вони були максимально наближені до аналогічних моделей німецьких тролейбусів. Запропонована методологія та структура дослідження в подальшому може бути використана для написання статей з історії науки й техніки, зокрема електротранспорту.

Ключові слова: *електротранспорт; тролейбус; експлуатація; машина; Чернівці; Німеччина*

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Троллейбусы “MAN” в Украине (1939-1951): история, технические характеристики, особенности эксплуатации

Аннотация. *Рост автомобильного парка и автобусных перевозок в городах Украины повышает уровень загрязненности окружающей среды. В условиях экологического кризиса электротранспорт становится объектом научных исследований, предметом дискуссий в среде политиков и общественных деятелей. В программе развития муниципального хозяйства Украины приоритетным является совершенствование инфраструктуры экологического транспорта: троллейбусов, электробусов, электромобилей. Повышенное внимание к электротранспорту со стороны научного сообщества, политических деятелей и общественности актуализирует исследования его истории, развития, особенностей эксплуатации и т.п. Проведенный авторами историографический анализ дает основания говорить о недостаточном освещении украинскими исследователями ряда аспектов и периодов в истории электротранспорта. Незначительное количество специальных работ, посвященных истории эксплуатации троллейбусов иностранного производства в украинских городах в первой половине XX в. и анализу их технических характеристик, обуславливают актуальность и научную новизну данного исследования. При написании работы были использованы украинские и зарубежные научно-справочные издания, монографии, статьи, в основном из зарубежных электронных ресурсов. Авторами были применены как общенаучные (анализ, синтез, дедукция, индукция), так и собственно исторические методы исследования, в частности проблемно-хронологический, сравнительно-исторический, ретроспективный методы и др. Целью исследования является освещение малоизвестных фактов,*

касающихся истории производства и эксплуатации в украинских городах троллейбусов "MAN", а также введение в научный оборот их технических характеристик. Установлено этимологию названий моделей немецких троллейбусов. Название обычно состояло из названий заводов-производителей шасси, кузова и электрооборудования. Определены типы, специфические конструктивные решения троллейбусов "MAN" первого поколения и предпосылки их появления в Черновцах. Особое внимание сосредоточено на троллейбусах, которые были в эксплуатации в Германии и других западноевропейских странах с первой половины 1930-х гг. до начала 1950-х гг. В середине 1930-х гг. выпуск троллейбусов начал завод "MAN" в Нюрнберге, его модели имели самые современные на то время конструктивные решения, характерный дизайн и новую систему отопления. В зависимости от длины немецкие производители разделяли модели троллейбусов на четыре типа. Вследствие проблем с эксплуатацией автобусного парка в Черновцах, городские власти приняли решение о строительстве в городе троллейбусной линии; было закуплено четыре троллейбуса производства завода "MAN". В статье прослеживаются этапы эксплуатации троллейбусов "MAN" в Черновцах, где они работали в течение 1939-1944 гг., а после окончания Второй мировой войны были переведены в Киев. После двухлетней эксплуатации в столице троллейбусы в течение 1947-1951 гг. выходили на маршруты в Днепропетровске. Приведены и проанализированы технические характеристики троллейбусов "MAN" первого поколения, которые эксплуатировались в украинских городах. Определено, что по всем основным показателям и эксплуатационным параметрам они были максимально приближены к аналогичным моделям немецких троллейбусов. Предложенная методология и структура исследования в дальнейшем может быть использована для написания статей по истории науки и техники, в частности электротранспорта.

Ключевые слова: *электротранспорт; троллейбус; эксплуатация; машина; Черновцы; Германия*

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Characteristics of unpaved roads in the late 18th century – early 19th century, and the design of the first wooden trackway as a forerunner to the Bukovyna railways

Abstract. *In the history of Bukovinian social life in the 1840–1850s, an important role is played by the fierce struggle for the introduction of rail transport. This struggle took place in the deepening crisis of the feudal system and the development of capitalism in the Austrian Empire. Primitive medieval methods of transporting goods and passengers by waterways and unpaved roads, which for centuries met the needs of feudal Bukovyna, became a brake on the economic, social and political progress of the Bukovyna region. The beginning of the transport revolution in England had a huge public response in Austria-Hungary. The rapidly developing relationship between scientists and engineers from Austria, Western Europe and America in this period made a large contribution to the process, as the newest means of transportation were spreading in the early 19th century, first of all, in the industrialized regions of Europe. These regions had enough funds for the construction of roads because they could develop different methods of production. Today we are mostly interested in the projects of construction of typical means of transportation on agricultural lands with practically no industry. In the early 19th century, Bukovyna was one of them. The purpose of this article is to thoroughly analyze unpaved roads of the late 18th – early 19th century, as well as the project of the first wooden trackway as the forerunner of the Bukovyna railways. To achieve this purpose, the authors first reviewed how railways were constructed in the Austrian Empire during 1830s – 1850s. Then, in contrast with the first railway networks that emerged and developed in the Austrian Empire, the authors made an analysis of the condition and characteristics of unpaved roads in Bukovyna. The*

government's attention to Bukovyna's roads was explained by their military, economic and political significance for the Austrian Empire by the end of the 18th – early 19th century. There was a number of state trackways built on the territory of Bukovyna which crossed the region and ensured the military interconnection of two Austrian provinces named – Galicia and Transylvania, as well as approached the borders of the Russian Empire and the Danube principalities. At the same time, they helped to restore the suspended trade flow in Bukovyna. In addition, the authors considered the first attempt to create a wooden trackway as a prototype and predecessor of the Bukovyna railway. It is evident that such an idea played a significant role in shaping the development strategy of the region in the minds of Austrian and Bukovinian officials, and became a forerunner for main and regional railways in Bukovyna.

Keywords: *Austrian Empire; transport; construction of railways; periodization; ways of communication of Bukovina*

Introduction.

The development of railway construction in the Austrian Empire in the 19th – early 20th century can be divided into 4 related chronological periods:

1) the first period of private railways (from the beginning of construction till 1841);
2) the first period of state railways (1841–1854);
3) the second period of private railways (from 1854 till the economic crisis in 1873);
4) the second period of state railways (from 1873 till the collapse of the Austro-Hungarian Monarchy in 1918).

Of course, each period had its own differences, although they were all characterized by fluctuations between the two systems of railway construction and operation, namely, private and public. In general, the history of railway construction on the territory of modern Austria is quite interesting and educative (Strelko, Berdnychenko, & Pylypchuk, 2021). It is thoroughly described in the publication "The Development of Railways In the Austrian Empire: From the Beginning of Construction to 1854" by I. V. Zhaloba (1995) (Zhaloba, 1995). As it turned out, wooden trackways were first mentioned in the Austrian chronicles in the late 16th century. Such trackways were used to take coal and ore out of the mines. For reference, it took 50 years before this system appeared in England in the early 18th century. However, England was the first to replace wooden tracks with iron in the early 18th century and combine them with steam in the early 19th century. The opening of the Liverpool-Manchester Steam Railway on August 15, 1830, and its positive operating experience had revolutionary consequences for the European communications routes in the 19th century (Georgievskiy, 1893).

It is believed that Austria understood the importance of new types of trackways quite early. The process was initiated by Franz von Gernster, the Principal of the Prague Polytechnic University. On December 31, 1807, he addressed the Bohemian Hydraulic Society with a proposal to build a railway between the rivers Danube and

Moldova (Verhovskiy, 1892, p. 18). However, he was actively defending artificial rail roads after Napoleon's invasion in 1813 (Promyishlennost i tehnika, w.y., p. 87). It was his son, Franz Anton von Gernster, Professor at the Vienna Polytechnic, who obtained permission to build a wooden horse-drawn railroad between Mauthausen and Budweiss on September 7, 1824. The road was designed to transport salt from Bohemia. A year later, the First Austrian Railway Company began to build its first railway. The Budweis Railway was launched on September 7, 1827, with only 7 miles of track, and was completed on April 1, 1833. It was the first railway (although horse-drawn) built on the European continent.

It should be noted that the slow construction of the first railways in Austria was grounded by the lack of experience in track construction. Yes, it was believed that the railways should only be built on a flat surface, because train wheels would slide on the slopes. Other engineers believed that one earth mound could not be enough for safe movement. Therefore, they first installed the stone foundation, and then covered it with earth. That is why the construction of railways was expensive and, moreover, very slow.

The purpose of this article is to thoroughly analyze unpaved roads of the late 18^{th} – early 19^{th} century, as well as the project of the first wooden trackway as the forerunner of the Bukovyna railways.

Research methods.

To achieve this purpose, the authors first reviewed how railways were constructed in the Austrian Empire during 1830s – 1850s. Then, in contrast with the first railway networks that emerged and developed in the Austrian Empire, the authors made an analysis of the condition and characteristics of unpaved roads in Bukovyna. The government's attention to Bukovyna's roads was explained by their military, economic and political significance for the Austrian Empire by the end of the 18^{th} – early 19^{th} century. There was a number of state trackways built on the territory of Bukovyna which crossed the region and ensured the military interconnection of two Austrian provinces named Galicia and Transylvania, as well as approached the borders of the Russian Empire and the Danube principalities. At the same time, they helped to restore the suspended trade flow in Bukovyna.

In addition, the authors considered the first attempt to create a wooden trackway as a prototype and predecessor of the Bukovyna railway. It is evident that such an idea played a significant role in shaping the development strategy of the region in the minds of Austrian and Bukovinian officials, and became a forerunner for main and regional railways in Bukovyna.

Results and discussion.

How Railways Were Constructed in the Austrian Empire in the early 1830 s – late 1850 s.

Somewhere in the mid-1830s, right before the construction of railways for steam

locomotives in England, Austria built about 250 km of horse-drawn railways. Noting this fact, I. V. Zhaloba asked: "How did it happen that the Habsburg Monarchy could get proper support from the public, private capitalists and the government, and build the first railway on the European continent?" The answer is: "Let's consider an aspect emphasized by K. Gudechek. Unlike England, which had sea routes due to its insular position, and Germany, which had an extensive network of river routes, Austria, due to its predominantly mountainous terrain in the pre-railway era, was deprived of these convenient and cheap means of transportation ... According to P. I. Georgievskiy, the export goods from Austria and Hungary was impossible at the end of the 18th century due to the poor condition of the roads: the cost of transporting goods to the border exceeded their value. Modern Austrian historians also believe that it was due to the high level of technical education" (Zhaloba, 1995, p. 48).

Of course, another important factor was the hope of large private capitalists to receive significant revenues from railway transportation. The positive experience of the Liverpool and Manchester Railway had shown the advantage of rail transport and its financial benefits. Austrian engineers went to England to study the experience of using steam locomotives. They did not passively learn from others but made their best contribution to the improvement of railway trains immediately upon return. It was decided to build a steam railway that would connect Vienna with the salt companies in Bochnia (Galicia) (Wandruszka & Urbanitsch, 1973, p. 278).

The construction of railways in the Austrian Empire had been delayed for a long period of time. The reason was that the first railways, whether horse-driven or carrying steam locomotives, were mainly built with private initiative and funded from private companies on the basis of concessions issued by the government. I. V. Zhaloba noted: "Such concessions contained great privileges for entrepreneurs, providing an unlimited scope of business activities. In 1838, the government made its first attempt to create a background for the legislative regulation of the railway business. According to the governmental decrees, private companies could decide upon the direction and sequence of railroads, based on their previous profitability calculations. The state could intervene only when the net profit exceeded 15% of deposits. In general, although the decrees contained certain restrictions (for example, the Vienna-Raab Railway was built on the basis of these decrees, and the concession granted to Simon Sini was different from the one granted to Rothschild), they did not have any radical impact neither on railway construction nor on the tariff form" (Zhaloba, 1995, p. 50).

Between 1845 and 1849, Austrian railways made their first attempts to unify with the German railways (Wandruszka & Urbanitsch, 1973, p. 280). The so-called Northern Railway was the most successful example. Unlike other private railways, it has successfully overcome the first difficult period thanks to state loans, private capital and the necessary administrative measures. In the mid-1840s, this railway demonstrated high profits (for example, 6.79% in 1846) (Praschinger, 1989, p. 102,

104). It should be added that the Northern Railway had the highest wages among private railways in Austria. Moreover, this railway had the lowest fare, and the highest accuracy of trains.

In general, railway construction in Austria in the 1840s did not stop. However, despite the fact that the Habsburg Monarchy was not the last European state to build a railway, it definitely could not overcome the necessary pace of large-scale development of the railway network. The main reason for this was the economic crisis caused by the conservative political system. Moreover, it was at that time, namely until 1845, that the share price fell sharply. This led to the collapse of most private railways. The construction of the railway network stopped, as did the empire's credit system, so the state was forced to take decisive measures. On July 10, 1845, a law was issued to ban the issuance of concessions to private enterprises for the construction of railways (except for coal railroads). This ban lasted until 1850. In addition, in November 1846, the state created an Extraordinary Credit Fund at the State Debt Fund, and began to purchase shares of railway companies at prices that corresponded to their true value. This was a successful measure. The state used the previous reduction in the share price, which is why they were quickly bought out. The money received was directed to the construction of railways. As a result of this measure, there was a new artificial increase in the price of railway shares, but the state quickly suspended the purchase for a while to balance the price of shares. At the end of 1847, the state bought more than half of the issued shares. In general, the sum of state expenditures on these measures at the end of 1848 amounted to about 26 million guilders (Tsehanovetskiy, 1869, p. 162).

This measure caused the first actual nationalization of the railway network in Austria. The state became a co-owner of 50–60% of the shares, and consolidated its dominant position, which led to the expansion of a comprehensive state railway system. Thus, in 1850 the state started to create a number of administrative institutions: state railway directorates and administration (powiat) centers. It switched to the state operation of railways, because previously, even state-built railways had been put into operation by private companies. At that time, the state started to actively purchase private railways that were in a difficult financial situation. Also, one of the predominant factors for the purchase of railways was the financial state of some railway companies.

Along with the purchase of existing railways, the state continued to construct new ones in the 1850s. The construction continued even after 1854, when a new course was announced for the privatization of the railways. The outstanding achievements of the Austrian state at that time included the construction of a railway between Vienna and Trieste, the most significant achievement in the history of Austrian railways. Moreover, between 1854 and 1856 the state built a number of railways in Italy, Hungary and part of Galicia (now the territory of Poland). At the same time, the Oderberg, Dzidzice and Auschwitz section completed the construction of private Kaiser Ferdinand's Northern Railway, thus establishing the direct

connection between Vienna and Galicia planned 20 before that (Wandruszka & Urbanitsch, 1973, p. 282).

The intense activity of the state has been paid off: by 1854, when the private companies were allowed to construct railways again, the Habsburg Monarchy built the major part of state railways (1,852 km with a total length of 2,617 km). Compared to other European countries, this was a huge achievement. Thus, of the 371 million guilders spent on railways at the end of 1856, 291 million guilders came from the state (Wandruszka & Urbanitsch, 1973, p. 282).

From the review of railway development in the Austrian Empire from the beginning of construction to the late 1850s, we can conclude the following. During this period, the Austrian Empire managed to form a significant railway network, mostly in the central and western parts of the empire. Only after that, all the thoughts of the state turned to other subordinate territories, including Bukovyna.

Unpaved Roads in the Late 18th Century – Early 19th Century as a Forerunner to the Bukovyna Railways.

The social and economic development of Bukovyna can be characterized by the fact that this region was annexed to the Austrian Empire much later than other Ukrainian lands (Transcarpathia and Galicia). That is why the processes of colonization, development of agrarian relations, etc. took place in a very peculiar way. Its colonization was possible only after accumulating enough information not only about natural resources, but also about the means of communication, which were vital primarily due to changes in government.

By the time Bukovyna became part of the Habsburg Monarchy, the state of communication routes in the region had been very poor. Historical sources indicate that important international dirt roads and waterways (along the Dnieper) ran through Bukovyna since Middle Ages. However, at the end of the 18th century, there were only mentions of these routes, since all the trade flows had stopped. I. V. Zhaloba noted: "Politics was the determining factor of this phenomena" (Zhaloba & Yatsentyuk, 1997). The progressive decline of the Ottoman Empire that dominated in Bukovyna and the Moldavian principality since 1538 did not contribute to the revived economic and trade life. On top of that, the political instability of Bukovyna, and the frequent military clashes in Europe which affected Bukovyna one way or another, also complemented the disappointing state of the region's development. Poor economic development led to the fact that at the end of the 18th century, there were only unpaved roads in Bukovyna which became unpassable during the rains, especially in the mountains and swamps. There were few bridges, since the rivers usually turned into fords, and the existing bridges were kept in poor condition. The above factors slowed down the caravans during rains and spring floods, and they had to wait for the water to drop to cross the river (Krushevan, 1903, pp. 12–14). Historical sources also evidence that there was no regular trade and transport traffic on the waterways of Bukovyna. Only after Bukovyna became part of the Habsburg

Empire there was a change in political domination and peace in Bukovyna, and the region was included in the European civilization process. This process gradually contributed to a significant increase in domestic and foreign trade. This is when it became obvious that the road network in Bukovyna did not meet the requirements of the evolving economy. The network was forced to develop rapidly. The Austrian authorities understood that only by improving the means of communication they could create better conditions for the development of trade and economic activity in the Bukovyna region. By creating a network of good unpaved roads, Austria hoped to get the most out of the newly acquired Bukovyna territory. To that end, the authorities sought to include Bukovyna in their imperial economic complex as soon as possible and as strongly as possible (Georgievskiy, 1893, pp. 157–158). In general, at that time the course of the Austrian government towards the construction of roads in Bukovyna was very tangible and important (Kovalchak, 1988).

It is known that, unlike England and Germany, which could use cheap and convenient sea and river routes thanks to their geographical location, Austria did not have such an opportunity due to being a predominantly mountainous country. That is why at the end of the 18th century Austria found itself in a very difficult trade and economic situation: the poor condition of the roads made the export of goods almost impossible, since the cost of transporting goods to the border far exceeded their value. That is why the Habsburg Monarchy started to pay more and more attention to improving the network of unpaved roads (Kovalchak, 1988, p. 2; Hudeczek, 1918, pp. 19–20). Here is what I. V. Zhaloba says about this period: "Initially, the strategic aspect was the most important in relation to Bukovyna. The region provided a direct link between two Austrian provinces: Galicia and Transylvania. This circumstance was pointed out by the monarch Joseph II, who wrote in his letter of June 19, 1773 to Maria Theresa: "This acquisition (of Bukovyna) will not only facilitate trade and communications, but will also create an exit from one province to another for our troops, who are now forced to make a terrible detour." In addition, the very location of the region in relation to the Russian Empire and the Danube principalities made it strategically important" (Zhaloba, & Yatsentiuk, 1997, p. 728). Thus, the military, political and economic reasons determined the active improvement of communication routes in Bukovyna in the 18th century.

Gathering information about Bukovyna communication routes began long before the occupation of the region. Thus, in 1773, Colonel Baron von Enzerberg began gathering information, assisted by one officer and two non-commissioned officers. In general, they collected all sorts of information, but were forced to give comprehensive answers to 5 main questions. One of them was whether it was possible to build a good road from Transylvania to Galicia. This aspect, as it turned out later, was one of the main ones, as it outlined broad plans for road construction (Kaindl, 1894a, p. 10). Subsequently, information about the roads of Bukovyna was confirmed by various Austrian military topographic expeditions.

Bukovyna's occupation was prepared in advance and was complete in 1774. The military administration of the region was headed by General Spleny. During his rule between 1774 and 1778, 70 bridges were built in Bukovyna. This provided the Austrian troops with the possibility for maneuvering. In 1778, General Spleny was replaced by Baron von Enzenberg. Under his leadership, the military administration worked closely on laying the first unpaved roads in Bukovyna. For example, between 1778 and 1779 and in 1783 two roads were built on the territory of Southern Bukovyna, from Dorna to Rodna and from Poiana Stampei to Borgo (Kaindl, 1898, p. 69). At the same time, in Zastavna, Kuchimmar (now the village of Velykyi Kuchuriv, Storozhynets raion), Styrche, Granicesti, Vami and Poiana-Stampei, inns and trade traffic was established across Bukovyna, as well as several shelters for the troops (Polek, 1900).

If we analyze the contribution of the Austrian Empire to the development of the road network in Bukovyna, we can conclude that it has been impressive. During the Austrian reign (1774–1918) a network of state-wide, county-wide and local unpaved roads was created in the region. Among these roads, special attention was paid to state-wide roads, because they were of large trade, political and strategic importance for the state. Actually, these roads were constructed and maintained at the expense of the state treasury (Zhaloba, 1991).

In general, the Austrian government has consistently allocated significant funds for the construction and maintenance of state-wide roads in Bukovyna. Government's attention can be explained by the military, economic and political significance of these roads for the Austrian Empire. In the conflicts that arose in South-Eastern Europe, the Austrian government found a way to quickly deploy large number troops to the borders of the Russian Empire and the Danube principalities, and could put pressure on them if necessary. This was evidenced by the Russo-Turkish Wars (1806–1812, 1828–1829), and the Crimean War (1854–1858).

In 1849, Russian troops moved to Novoselytsia through the so-called Transylvanian and Military routes, as they were sent to help the Habsburgs in suppressing the Hungarian revolution (Kaindl, 1894b, pp. 48–51). That is why, under any circumstances, the state-wide roads ensured the movement of all types of troops and freight convoys. I. V. Zhaloba notes: "At the same time, starting from the late 18th century, the Austrian authorities began to use Bukovinian roads for economic purposes in order to ensure the fastest return from the newly acquired territory. Both the measures of the Austrian court and the peace established on Bukovinian land contributed to this process" (Zhaloba, & Yatsentiuk, 1997, p. 731).

Thus, a number of state-wide tracts were built in the late 18th – early 19th century, crossing the region and ensuring the interconnection between Galicia and Transylvania, approaching the borders of the Russian Empire and the Danube principalities. At the same time, they contributed to the restoration of long suspended trade flow in Bukovyna.

On the other hand, state-wide tracts, which remained major routes until the late 1900s, ensured a political and economic connection between Bukovyna and the center of the empire, serving as means of communication between Austria and Hungary and the East. The construction of non-state roads, which were of mostly regional importance, intensified the above processes. By the beginning of the 19th century, they existed as dirt roads and were mostly in poor condition. The gradual establishment or separation of economic and trade ties led to the emergence of roads and settlements through which both international and domestic traffic took place. In turn, paved roads in these areas, according to the rules of road art, created the conditions for the development of existing trade. Without any doubt, at the end of the 18th century – early 19th century, there was the basis for a permanent network of trackways, the predecessors of railways in Bukovyna. Later this network has improved both quantitatively and qualitatively, especially after the appearance of railways.

History of the First Wooden Trackway of Bukovyna.

In the history of Bukovinian social life in the 1840–1850s, an important role is played by the fierce struggle for the introduction of rail transport. This struggle took place in the deepening crisis of the feudal system and the development of capitalism in the Austrian Empire. Primitive medieval methods of transporting goods and passengers by waterways and unpaved roads, which for centuries met the needs of feudal Bukovyna, became a brake on the economic, social and political progress of the Bukovyna region. The beginning of the transport revolution in England had a huge public response in Austria-Hungary. The rapidly developing relationship between scientists and engineers from Austria, Russia, Western Europe and America in this period made a large contribution to the process (Voronin, 1974), as the newest means of transportation were spreading in the early 19th century, first of all, in the industrialized regions of Europe. These regions had enough funds for the construction of roads because they could develop different methods of production. Today we are mostly interested in the projects of construction of typical means of transportation on agricultural lands with practically no industry. In the early 19th century, Bukovyna was one of them.

One of the first questions about the need to build a wooden horse-driven trackway in Bukovyna was raised by Karl Wittek, the Secretary of the Court Chamber in 1841. He pointed that the construction of a trackway was of paramount importance for the economic development of Bukovyna, especially for large-scale forest exports (especially due to lack of human resources in mountainous areas). K. Wittek criticized the process of rafting the forest by the Bukovinian rivers and proved the dependence of river transport from nature. He stressed that Bukovinian forests could provide enormous volumes of wood and fantastic profits. K. Wittek hoped to sell the forest to Egypt and other parts of the Ottoman Empire without much difficulty. The brave entrepreneur proposed to solve this problem only by building a wooden horse-driven trackway. The trackways were not supposed to be made of iron,

but of wood. The thing is that at that time, the so-called American type trackways (wooden laths, lined with tin, longitudinal beams) were rather popular. Therefore, it was not a surprise that K. Wittek proposed this for Bukovyna. After all, iron trackways for this region were still very expensive. K. Wittek convinced everyone that wooden trackways could be built cheaper and faster than unpaved roads even 10 years later, in the early 1850s. The prospect of building wooden horse-drawn trackways was seriously considered to improve the routes in the eastern provinces of the Austrian Empire (Galicia and Bukovyna). The cost of a conventional railway was 3 times bigger than the cost of a wooden trackway. In addition, the transportation of goods via trackways was 3–4 times faster than via unpaved roads (Zhaloba, 1999). Appealing to the best international practices in the construction of the first wooden horse-driven trackways, K. Wittek made concrete proposals for the construction of two important branches – from Chernivtsi to Suceava as the main transshipment point on the Moldovan border, and from Poiana Stampei to Suceava through Transylvanian region near Solka to connect the forests of Bukovyna and Chernivtsi. These roads were to cross the forests and connect them with Transylvania and Moldavia. The second trackway was to become a hub for Bukovyna, since it connected Chernivtsi, the capital of Bukovyna, with forest reservations. K. Wittek proposed to start the construction from the second trackway, since in that case, all the wood required for the first trackway could be delivered from the state forests. This was extremely important, because the first trackway was to be laid in private areas with the withdrawal of land. It was believed that this withdrawal was not expensive, as the price of land in Bukovyna at that time was low (Botushanskyi, 2000). The second trackway was to be established mainly on state lands, so it could be finished at a lower cost.

K. Wittek believed that the construction of wooden horse-drawn trackways could be funded both from private and public sources. Still, he preferred state construction because the state had everything at its disposal to build a wooden trackway, and that made things much easier. Nevertheless, the project proposed by K. Wittek was not destined to come true. As we know, at that time Bukovyna was part of the Galician governorate. Therefore, the petition initiated by K. Wittek was sent to the Governor-General of Galicia, who had to present the conclusions of local institutions in this regard. On September 16, 1845, that is, two years after K. Wittek's petition, the President of the Court Chamber of Kübeck received a negative response from Archduke Ferdinand, the Galician military and civilian Governor-General. The answer stated that the project of K. Wittek “lacked the necessary knowledge of local conditions” and that his good intentions were not suitable for practical implementation. The relevant institutions that prepared this verdict pointed out two main statements: 1) there was no surplus wood in Bukovyna, since the area between Chernivtsi and Suceava was mostly forestless; 2) to deliver wood from remote places, they had to construct an additional 60-mile wooden trackway. Therefore, the trackway proposed by K. Wittek was unprofitable. In addition, the sale of wood in the Galati market, even under favorable conditions, could not give much benefit (Galati

is a port town in eastern Romania), because mast timber was much more valuable. For this reason, there was no sense in building a separate road. The Galician construction director stressed that there was not enough timber for shipbuilding in Bukovyna, and little firewood and building wood could be sold abroad.

Eisenbeck, an Austrian agent in Iasi, also made a conclusion about K. Wittek's project. On March 10, 1844, he announced that the Moldavian government did not expect the wooden trackway or railway to be extended through Moldova. Therefore, K. Wittek's project was also rejected. In addition, all the officials of the Austrian Empire agreed that Bukovyna had mountain rivers and streams that flew into the Siret and Prut, and that they would transport wood to both Moldova and Galati. Because of this, Dubeck wrote an official letter dated October 17, 1845, informing Archduke Ferdinand that he was terminating the case.

I. V. Zhaloba drew the following conclusion about the first wooden horse-drawn trackway in Bukovyna: "What's interesting, a year later, on January 17, 1845, Eisenbeck wrote about the lively interest aroused by the decision of the Austrian government dated December 18, 1844 to rebuild the Galician railway from Bochnia through Lviv to Chernivtsi at the expense of the state. Moreover, the position of the Moldavian noblemen was very active. They immediately started to form consortia that would be able to build a counter line from Galati through Iasi to the Austro-Moldavian border. Influential representatives of Moldovan landowners addressed both questions and suggestions to Eisenbeck about the state of the Galician railway, about the possible participation of Austria in the construction of the Moldovan railway, and so on. The above-mentioned agent stated this in his report to Kübeck on January 17, 1845. Kübeck's response was swift and categorical: Eisenbeck was strictly ordered to refrain from any statements or explanations that could give rise to any hopes or conjectures on the part of Moldova. To one degree or another, all this was done with the construction of the railway from Lviv through Chernivtsi to Iasi in 1860s, and with the construction of Bukovinian local and timber railways in the late 1980s – early 20th century. However, K. Wittek's project is of exceptional interest as a model of state thinking of that time, a way of bringing something fresh to the old soil. On the one hand, there is colonization and homesteads as a tribute to the old regulations of the obsolete era. On the other hand, there is a belief in the need to spread a new means of transport, thereby raising the price of land and livelihoods, and the desire to take advantage of the current favorable situation for a painless land expropriation to avoid unnecessary costs in the future. The fact that the local authorities did not even want to design this trackway is also a good example of the inertial Austrian bureaucracy at that time" (Zhaloba, 1999).

This was the first attempt to build a wooden trackway in Bukovyna. This very idea, of course, played a role in shaping the development strategy of the region in the minds of Austrian and Bukovinian officials, and became a forerunner for main and regional railways in Bukovyna.

Conclusions.

In the late 18th century – early 19th century, a developed network of unpaved roads was laid in Bukovyna as the basis of a permanent road network, the predecessors of railways. Later this network has improved both quantitatively and qualitatively, especially after the appearance of railways.

The construction of the first horse-drawn trackway in Bukovyna would not be of great importance for the region, but the experience of its construction and operation would not only prove the possibility of uninterrupted operation in all seasons, but also the relevance of railway construction. The commercial operation of this road could also show the feasibility and profitability of new means of transport. At the same time, this trackway would become the first step in the organization of the railway business in Bukovyna, and could serve as an impulse for the development of the railway industry in the Bukovyna region.

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Характеристика грунтових доріг кінця XVIII – початку XIX ст. та проєкт першої дерев'яної колійної дороги як попередників залізничних шляхів Буковини

Анотація. *В історії буковинського суспільного життя 40–50-х років XIX ст. важливе місце займала гостра боротьба за впровадження залізничного транспорту. Ця боротьба протікала в умовах поглиблення кризи феодально-кріпосницької системи і розвитку капіталізму в Австрійській імперії. Примітивна середньовічна техніка перевезення вантажів і пасажирів водними шляхами і ґрунтовими дорогами, яка сторіччями задовольняла потреби феодально-кріпосницької Буковини, на початку XIX ст. все більше і більше ставала гальмом на шляху економічного і соціально-політичного прогресу буковинського краю. Початок транспортної революції в Англії мав величезний суспільний резонанс в Австро-Угорщині. Цьому сприяла наявність в даному періоді наукових зв'язків, що активно розвивалися, між австрійськими, західноєвропейськими і американськими вченими, інженерами і техніками. Бо новітні засоби транспортування поширювалися в першій половині XIX ст., в першу чергу, в промислово розвинутих регіонах Європи. В цих районах були кошти для будівництва шляхів сполучення, адже завдяки останнім могло розвиватися різне виробництво. Сьогодні для нас мають важливий історичний інтерес ті проєкти, які стосувалися будівництва характерних на ту пору*

засобів транспортування на аграрних землях, де промисловості майже не було. І до таких аграрних земель в першій половині XIX ст. в австрійській державі належала Буковина. Метою даної статті є ґрунтовний аналіз характеристик грунтових доріг кінця XVIII – початку XIX ст. та проєкту першої дерев'яної колійної дороги як попередників залізничних шляхів Буковини. Для досягнення поставленої мети, авторами спочатку виконано огляд процесу будівництва мережі залізниць в Австрійській імперії, за період першої половини 1830-х – другої половини 1850-х років. У порівнянні з досвідом появи та розбудови перших мереж залізниць у Австрійській імперії загалом, наведено аналіз стану та характеристик ґрунтових доріг Буковини. Увага уряду до розвитку шляхів Буковини пояснювалася військово-стратегічним та торгово-економічним і політичним значенням їх для Австрійської імперії. У кінці XVIII – першій половині XIX ст. на території Буковини було споруджено ряд державних трактів, які, перетинаючи край, забезпечували військовий взаємозв'язок двох австрійських провінцій – Галичини та Трансильванії, а також впритул підходили до кордонів Російської імперії та Дунайських князівств. У той же час вони сприяли відновленню значно призупиненого торгового руху Буковиною. Розглянуто першу спробу створити дерев'яну колійну дорогу, як прототип та попередник залізниці на Буковинських землях. Показано, що сама така ідея, безумовно, відіграла свою роль у формуванні стратегії розвитку краю в головах австрійських і буковинських чиновників, та стала передвісником подальшого будівництва магістральних та регіональних залізниць на Буковині.

***Ключові слова**: Австрійська імперія; транспорт; будівництво залізниць; періодизація; шляхи сполучення Буковини*

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Характеристика грунтовых дорог конца XVIII – начала XIX в. и проект первой деревянной колейной дороги как предшественников железнодорожных путей Буковины

***Аннотация.** В истории буковинской общественной жизни 40–50-х годов XIX ст. важное место занимала острая борьба за внедрение железнодорожного транспорта. Эта борьба протекала в условиях углубления кризиса феодально-крепостнической системы и развития капитализма в Австрийской империи. Примитивная средневековая техника перевозки грузов и пассажиров по водным путям и грунтовым дорогам, которая столетиями удовлетворяла потребности феодально-крепостнической Буковины, в начале*

XIX в. все больше и больше становилась тормозом на пути экономического и социально-политического прогресса буковинского края. Начало транспортной революции в Англии имело огромный общественный резонанс в Австро-Венгрии. Этому способствовало наличие в данном периоде активно развивающихся научных связей между австрийскими, западноевропейскими и американскими учеными, инженерами и техниками. Ибо новейшие средства транспортировки распространялись в первой половине XIX в., в первую очередь, в промышленно развитых регионах Европы. В этих районах были средства для строительства путей сообщения, ведь благодаря последним могло развиваться разное производство. Сегодня для нас имеют важный исторический интерес те проекты, которые касались строительства характерных на то время средств транспортировки на аграрных землях, где промышленности почти не было. И к таким аграрным землям в первой половине XIX в. в австрийском государстве принадлежала Буковина. Целью данной статьи является основательный анализ характеристик грунтовых дорог конца XVIII – начала XIX ст. и проекта первой деревянной колейной дороги в качестве предшественников железнодорожных путей Буковины. Для достижения поставленных целей авторами первоначально выполнен обзор процесса строительства сети железных дорог в Австрийской империи, за период первой половины 1830-х – второй половины 1850-х годов. По сравнению с опытом появления и развития первых сетей железных дорог в Австрийской империи в целом, приведен анализ состояния и характеристик грунтовых дорог Буковины. Внимание правительства к развитию путей Буковины объяснялось военно-стратегическим и торгово-экономическим и политическим значением для Австрийской империи. В конце XVIII – первой половине XIX в. на территории Буковины был построен ряд государственных трактов, которые, пересекая край, обеспечивали военную взаимосвязь двух австрийских провинций – Галиции и Трансильвании, а также вплотную подходили к границам Российской империи и Дунайских княжеств. В то же время они способствовали возобновлению значительно приостановленного торгового движения по Буковине. Рассмотрена первая попытка создать деревянный путь, как прототип и предшественник железной дороги на Буковинских землях. Показано, что сама такая идея, безусловно, сыграла свою роль в формировании стратегии развития края в головах австрийских и буковинских чиновников и стала предвестником дальнейшего строительства магистральных и региональных железных дорог в Буковине.

Ключевые слова: *Австрийская империя; транспорт; строительство железных дорог; периодизация; пути сообщения Буковины*

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