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PREFACE

The issue of the journal begins with an article on French sinology. French sinology takes a special place in the history of the sinological studies development. It was France that became the first country where the transformation of missionary sinology, which was common among a limited circle of researchers (mainly in a religious sphere), into the academic scientific discipline, which had already been taught and studied at a professional level in academic institutions, occurred. The Parisian type of sinology used to dominate the entire world for a long time, including such powerful centers of Chinese studies as Germany, Great Britain, the USA, and China itself. In order to form a complete picture of sinology development in France, the authors singled out and analyzed three historical periods covering the entire history of Chinese studies development, starting from its birth and flourishing to the process of stagnation.

Modern scientific communication traditionally uses visual narratives, such as comics, for education, presentation of scientific achievements to a mass audience, and as an object of research. In the article by Oksana Hudoshnyk and Oleksandr P. Krupskyi, offers a three-level characterization of the interaction of comic culture and science in a diachronic aspect. Attention is focused not only on the chronological



stages of these intersections, the expression of the specifics of the interaction is offered against the background of scientific and public discussions that accompany the comics–science dialogue to this day. Emphasis is placed on the unique phenomenon of the simultaneous concordance of various stages of the dialogue between comics and science, on the prolonged replication of successful inventions into modern experience, and the active testing of known narratives at new levels of a scientific presentation.

The next paper assesses the topicality of Vernadsky's concept of the noosphere, coined over almost twenty years starting in the early 20th century. Emphasizing the uniqueness of Vernadsky's concept of the noosphere as the transformation of the biosphere by a man using reason, we concentrate on the assessment of the utopian or realistic nature of his vision of the future of humanity. Based on the philosophical case-studies analysis, it identifies the ideological roots of the noosphere concept, the development of views on the concept in time, the role of reason and scientific thinking, the opinions of its supporters and critics, and Moiseev's related concept of co-evolution.

Lectures de Potentia Restitutiva or *Of Spring: Explaining the Power of Springing Bodies* (1678) is an important book for the history of science. This book is better known for Hooke's presentation of the law that bears his name. In the article by Isadora Monteiro, seeks to study the *Lectures de Potentia Restitutiva* once again to better understand Hooke's thoughts about the rule which bears his name and his conception of gravity, which the author considered a force. Here Hooke's definitions of body and motion will be presented, as well as his actual objective when he formulated the so-called Hooke's Law. As we will see, Hooke intended to create a "philosophical scale" to measure the gravitational attraction between bodies. By considering his previous publications, such as *An attempt to prove the motion of the Earth from Observations or Micrographia: or some Physiological Descriptions of Minute Bodies*, or even unpublished works such as *On the inflection of a direct motion into a curve by supervening Attractive principle*, it becomes clear that Hooke was already opening a path toward an understanding of gravity before Newton's *Principia* (1687) were published. By taking into account the controversy between Isaac Newton and Robert Hooke, we also intend to strengthen the idea that Hooke was an indispensable contributor to the elaboration of a law of universal gravitation.

In 1915, the first occupational therapy school was founded by Jane Addams at Hull House (Chicago, USA). In that process, Addams inspired the first generation of occupational therapists, especially Eleanor Clarke Slagle. Thus, in the article by Rodolfo Morrison seeks to highlight the contribution of Jane Addams to the development of Occupational Therapy through an in-depth bibliographic review, from primary sources.

The next article presents the results of a study of the features of biographical and prosopographic materials about famous mathematicians and natural scientists, published in one of the most authoritative journals "Bulletin of Experimental Physics and Elementary Mathematics", which was published in Kyiv and Odesa during 1886–1917. In fact, the journal was an unofficial periodical printed branch of the Mathematical Department of the Novorossiysk Society of Naturalists.

The aim of the next research is to study the policy efforts conducted by the

Indonesian government since the beginning of independence in 1945 to present, in advancing science and technology and innovation. A content analysis approach is employed to identify each stipulated regulation in Indonesia in the form of Laws, Government Regulations, Presidential Regulations, Presidential Decrees, and Presidential Instructions. There are 78 regulations in the field of science and technology and innovation that are analyzed. The results of the analysis are described based on the emergence of regulations and institutional implications generated as part of the ecosystem.

In the article by Ihor Annienkov, based on the problem-chronological, comparative-historical, historiographical, and source-research methods, as well as the method of actualization, identifies the extent of borrowing foreign design and technological solutions in the Ukrainian Soviet Socialist Republic for projecting electrical machines in the second half of the 1930s, as well as the reasons for the absence of unambiguous information in historiography regarding the existence of this phenomenon in the republic at this chronological stage. The publication provides a general assessment of the quality of scientific support for the processes of creating electrical machines, establishes the ways of fulfilling the scientific-technical borrowings that were studied and the dynamics of their development, analyzes their role in the growth of the technical level of products of the Ukrainian electrical machine-building branch.

In the article by Mykola Ruban and Andrii Fomin, attempts to investigate the historical circumstances of the mastering and development of the industrial production of rolling stock in Ukraine from 1991 to 2021. In the course of the scientific development of the proposed research, materials from mass-circulation newspapers, industry publications of railway transport, as well as technical studies of employees of manufacturing plants were used.

The next discusses the conditions and prerequisites for choosing the location of the plant; considers the stage of the establishment (foundation) of the plant; examines the stage of plant construction and equipping it with technological facilities in detail; analyzes the development and establishment of the plant between 1897 and 1914. A brief analysis of locomotive designs produced by the Kharkiv Locomotive Plant from 1897 to 1914 has been made. The article shows the significance of Consultative Congresses of Traction Engineers for the development of railway machinery both at Kharkiv Locomotive Plant and for the entire railway industry.

The purpose of next study is to highlight the peculiarities of the development of the Russian aviation industry during the First World War. The focus is on analyzing production programs and matching their quantitative and qualitative parameters to war requirements. Production plans of leading Russian aviation factories as well as qualitative and quantitative parameters of products have been analyzed in the article.

HISTORY OF SCIENCE

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French sinology development (13–21 centuries): historical aspect

Abstract. *French sinology takes a special place in the history of the sinological studies development. It was France that became the first country where the transformation of missionary sinology, which was common among a limited circle of researchers (mainly in a religious sphere), into the academic scientific discipline, which had already been taught and studied at a professional level in academic institutions, occurred. The Parisian type of sinology used to dominate the entire world for a long time, including such powerful centers of Chinese studies as Germany, Great Britain, the USA, and China itself. The conducted historiographical analysis of the topic allows pointing out the insufficient coverage by the local researchers of the*



evolution of French sinology historical development as a whole process that had lasted for almost 800 years. This fact prompted the authors to reveal the mentioned topic. The purpose of the article is to investigate the historical development of French sinology during the 13th–21st centuries. In the course of the work, both general scientific methods and special ones were used, among which the priority was given to historical, chronological and problem-thematic methods. The analytical method and methods of grouping and typology were also applied, that made it possible to present the material in a logically complete manner. In order to form a complete picture of sinology development in France, the authors singled out and analyzed three historical periods covering the entire history of Chinese studies development, starting from its birth and flourishing to the process of stagnation. Thus, within the time limits of the first period, the process a peculiar scientific base of knowledge about China accumulating, as well as the development of missionary sinology, was investigated, and it was proved that it became a kind of bridge between the protosinological stage and academic sinology, which secularized the achievements of its predecessors in the 19th century and turned into a scientific academic discipline. Within the time limits of the second period, the scientific achievements of a whole galaxy of French scholars were analyzed, namely, Edouard Chavannes, Marcel Granet, Henri Paul Gaston Maspero, and others, and it was concluded that the Sinological school in France was at the peak of its development, and the views of its representatives gained priority among sinologists all over the world. Regarding the third period, the authors express the opinion that modern French sinology has lost its leading position in the scientific world, and the search for the latest methodological approaches and methods (primarily multidisciplinary with the use of digital technologies) is primarily an attempt to achieve parity with the leading centers of Chinese studies. Factual research material can be used for further study of the history of sinology development, as well as for writing generalising papers on Chinese studies, reading lecture courses, special courses and special seminars.

Keywords: *China; history of science; protosinology; missionary sinology; academic sinology; multidisciplinary approach*

Introduction.

Chinese civilization is one of the oldest civilizations in the world, which continuous historical tradition constantly attracts the attention of politicians, historians, and cultural experts. In addition, the country's distinctive policy of isolation, which has prevailed for centuries, increases the scientific community's interest in the historical and cultural development, as well as the peculiarities of the unique self-identity and outlook of the Chinese people formation. That is why sinology or Chinese studies, which includes a complex of separate scientific fields that study the history, politics, philosophy, and culture of China, is very popular among researchers.

In view of this fact, the study of the sinology development in France is of a great interest, whereas it is one of the first countries in which Chinese studies were born. This is the country in which sinology grew from missionary sinology to exclusively academic, the country that gave the world outstanding sinologists who enriched world Chinese studies with their fundamental research. Scientific understanding of the history

of French sinology development will allow supplementing the knowledge about the evolution of Chinese studies in the 13th–21st centuries as a component of the scientific picture of the worldformation. That is why the chosen topic has scientific and general humanitarian significance, which determines its relevance.

Analyzing historiographical research aimed at revealing this topic, its complete originality in the field of historical science can be noted. In general, the historical development of French sinology was researched by scholars in a somewhat fragmentary way, mostly in the context of global Chinese studies development. In particular, the methodological basis of the sinology study is highlighted in the article “Disciplinary and methodological features of the science about China” (Kiktenko, 2017). Among the scientists who researched particular periods of French sinology historical development, the works of Chinese scholars Pan Feng-Chuan (Feng-Chuan, 2020) and Sangkeun Kim (Kim, 2004) are worth pointing out. They mainly focused on the study of the so-called “missionary sinology”. This topic is also revealed in the work “Jesuits” (Lakutiur, 2011), in which the history of the Jesuit order is analyzed and the activities of its French representatives at the Chinese Emperors’ court are described in detail.

The first two hundred years of French sinology formation were analyzed in the work “Jean-Pierre Abel-Remusat Et Ses Successeurs. Deux Cents Ans De Sinologie Francaise En France Et En Chine” (Will & Zink, 2020). The main trajectories of the research conducted by a founder of the French Sinological School, Jean-Pierre Abel-Remusat, are described in the article “Research on the Tao te Ching in Europe in the first half of the 19th century” (Kapranov, 2021).

Current trends in the development of Chinese studies in France are reflected in the articles “Modern Chinese History in France” (Henriot, 2020), “Current trends in Chinese studies in France” (Bastid-Bruguière, 2008). New methodological approaches of French sinology are traced in the works of French sinologists Catherine Jami, Karine Chemla, the scientists François Jullien and Gilles Guiheux. It is worth noting that the works of Chinese scholars from the end of the 20th to the first third of the 21st century are related to the study of various aspects of Chinese development from ancient times to the present, namely, the history of mathematics (Jami, 2018), (Chemla, 2012), philosophy (Jullien, 2000), history and sociology (Guiheux, 2002, 2012). At the same time, a lack of complex research devoted to the study of the history of French sinology evolution during the 13th–21st centuries, which prompted the authors to disclose this topic.

The purpose of the article is to analyze the historical development of French sinology during the 13th–21st centuries on the basis of scientific sources and achievements of historiography, using modern methods and principles of scientific and historical knowledge.

Research methodology.

The methodological basis of the work is formed by general scientific methods (methods of empirical cognition), as well as special methods: historical, chronological, and problem-thematic. The usage of both logical and analytical, and methods of

grouping and typology allowed to classify homogeneous events and consistently present the material of the article, giving it logical completeness. Historical and problem-chronological methods were used to reveal the process of French sinology development during the period. In the process of working on the topic, the principles of objectivity and impartiality took an important place, which helped to give a balanced assessment to the scientific works of French sinologists. Thus, the usage of a range of research methods contributed to comprehensive and systematic coverage of the chosen topic.

Results and discussion.

Given the current methodological guidelines and the specifics of the chosen topic, as well as taking into account the entire historiographical spectrum of the formation and development of sinology in France, three historical periods have been identified. In particular, the first period, which lasted from the 13th to the 18th century, includes the stage of the initial knowledge about China accumulation (which we characterized using the term “protosinology”), the first attempts to describe the traditions and customs of its inhabitants, translations of original sources from Chinese into Latin, i.e. the formation of a knowledge base about Chinese civilization and progressive transformation of France into a center of Chinese studies. Historiographical achievements of French sinologists of the 14th– the first half of the 20th century belong to the second period. The third period contains modern historians’ works.

The first period (13th– early 17th century) is associated exclusively with the works of missionary monks who visited China and left their memoirs about it. That is why the first European recalling about China in historiography dates back to the 13th century. It is associated with the name of the Flemish Franciscan monk Guillaume de Rubruck (also known as William Rubruck), one of the first missionaries to visit the Middle East and Central Asia at the French King’s Louis IX request, in particular, the Mongol Empire (including China). After returning to his homeland, Rubruck described his journey to Khan Meng, calling the work “Itinerarium fratris Willielmi de Rubruquis” (Rubruck, 2012). The manuscript contained reflections about the Mongols, their traditions and customs, as well as the information about the actual course of the monk’s journey. In one of 40 chapters, where Rubruck described his theological debates with Buddhists and Muslims at the Mongol khan’s court, the participation of a representative from China is mentioned (Kim, 2004). These infrequent notes, made by monks about China, were the beginning of protoscientific research of the region.

More profound research of Chinese civilization began in the late 16th– early 17th centuries, but they are not associated with the names of the French, but of the Italian Jesuit missionaries: Michele Ruggieri and Matteo Ricci, who described their travels to China in their diaries. Later the expeditions of French missionaries set off to China, in particular, Nicolas Trigault, Joachim Bouvet, Etienne Fourmont, who, in turn, left their works to their descendants. Nicolas Trigault created one of the first systems of so-called Chinese romanization, when the Latin alphabet was used to transliterate Chinese hieroglyphs, and translated into Latin Matteo Ricci’s diary, in which the latter described his journey to China (Trigautio, 1615).

In the middle of the 17th century France, i.e. the capital city of Paris, has become a world center of sinology development. It is explained by the fact that the largest number of French Jesuit monks at that time held official positions at the Chinese imperial court. Among them were the physician and teacher of mathematics and astronomy, as well as the translator at Emperor Kansi's court Jean-Francois Gerbillon, the translator from Manchuria Joseph-Anne-Marie de Moyriacde Mailla, and the head of the French College in Beijing Antoine Gabil (Lakutiur, 2012, pp. 212–213). Thanks to the diligent work of the French, cartographic maps of that time territory of China were created, ancient Chinese historical and literary sources were translated into French, and descriptions of both Chinese emperors and their subjects' everyday life were compiled.

Within the chronological framework of the first period of French sinology development, the contribution of French historian Jean-Baptiste DuHalde, one of the first sinologists who approached the study of China exclusively from the scientific point of view, can be also noted. At the beginning of the 17th century, this Jesuit monk, who had never been to China and did not know Chinese, was able to summarize all the information that came to France from monks who carried out missionary work in the Chinese Empire. Thanks to his painstaking work aimed to systemize the collected facts, DuHalde managed to organize one of the most fundamental publications of the time – “Descriptions of the Chinese Empire”.

The information contained in the “Descriptions...” provided an opportunity to learn about the state system of China, the biographies of Chinese emperors, as well as the occupations, traditions and customs of the Chinese population. The publication was popular among researchers of the history of China in the 13th–17th centuries, as evidenced by its publications in different languages: Latin, English, and German.

Another encyclopedic issue edited by Jean-Baptiste DuHalde was also a four-volume “Geographical, historical, chronological and physical description of the Chinese Empire and Chinese-Tartary” (DuHalde, 1735), which was based on 27 tractates containing recollections of missionary monks who visited China.

The conclusion made by Pan Feng-Chuan, a professor of Department of East Asian Studies at the National Taiwan Normal University, is quite logical, that the scientific works of the Jesuits played a decisive role in laying the foundation for the further development of French academic Chinese studies (Feng-Chuan, 2020). The scientific world has even begun to discuss the possibility of bringing missionary sinology into a separate plane of science, turning it into an independent discipline, however, in our opinion, missionary sinology remains an integral component of sinological science, a kind of a scientific bridge between protosinology and scientific (academic) Chinese studies.

The second period of French sinology development, which began in the 19th century, is associated with flourishing of this scientific field. At first, Chinese studies were divided into two parts, religious (missionary) and secular, which developed in parallel, and then the priority shifted exclusively to academic sinology. This process is associated with the names of many talented scientists, among whom the figure of Jean-Pierre Abel-Remusat, the founder of the French Sinology School, stands out

undeniably (Will & Zink, 2020). The scientist, rejecting religious paradigms of the Jesuits, was one of the first in Western Europe who laid the cornerstone of scientific understanding of Chinese philosophy and wrote a scientific work devoted to the study and interpretation of the philosophical concept “Tao te Ching” (Kapranov, 2021, p. 6). Thanks to his scientific achievements, Jean-Pierre Abel-Remusat became widely known among sinologists, and when in 1814 the department of sinology was founded in one of the most prestigious and oldest Parisian academic institutions, the Collège de France, he was offered to head it. Since then, the study of Chinese history, culture, language and literature was added to the curricula of the country’s universities.

Famous French sinologists worked in the department in different periods of time, including Emmanuel-Edouard Chavannes, who chaired the department at the age of 28 and became its fourth head.

The scientist regarded the history of ancient China in the context of world history, without distinguishing it separately. Unlike his predecessors, the researcher adhered to the opinion that the history of China in the 19th century still remained unexplored, because until then the original historical chronicles, which, according to Édouard Chavannes, would be valuable sources for a comprehensive study of Chinese civilization, were not taken into account and therefore not translated into European languages (French or English). That is why Chavannes turned his attention to one of the most famous Chinese works “Historical Records”, written by ancient Chinese historian Sima Qian, a creator of his own cyclical approach of philosophy of history, who using the method of personification and emphasizing the exceptional role of personality in history, described two thousand and a half years of ancient China history during the reigns of the Xia, Shang Yin, Zhou, Qin, Han dynasties. The translation of 47 (out of 130) chapters of this fundamental ancient work into French belongs to Chavannes.

In addition to Chinese originals translation, the historian was also the first to conduct archaeological research in China, aiming to create a holistic scientific history of China.

During his lifetime, Édouard Chavannes wrote several thorough works, including “Voyage des Pélerins bouddhistes. L’Itinéraire d’Ou-K’ong (751–790)” (Chavannes, 2018), “Le t’Ai Chan: Essai de Monographie d’un Culte Chinois; Appendice, le Dieu du Sol dans la Chine Antique” (Chavannes, 2018), etc., in which he focused on the issues related to chronology of ancient China history, the peculiarities of religious cult, ideology and culture of its inhabitants.

Considering the development of scientific French sinology in the second half of the 19th– early 20th century, a famous scientist Marcel Granet is worth mentioning. Being a student of both Édouard Chavannes and sociologist Émile Durkheim, in his scientific research Marcel Granet was the first to use sociological methods in the study of the history, philosophy and culture of ancient China. Initially, Granet’s interests were limited to Japan, but later, after learning about the history of China the scientist became interested in this country. In 1911–1913, the scientist was on a business trip to Beijing, where he witnessed the revolutionary events during which the Qin imperial family abdicated (Granet, 2013).

After returning to Paris in 1919, Marcel Granet defended his thesis and received a doctorate. The thesis on “Ancient Chinese Holidays and Songs” was the first thorough study on China by a scientist (Granet, 1982).

During 1929–1943, two more Granet’s works were published, which became classics of French sinology – “Chinese Civilization” and “Chinese Thought”. They demonstrated the effect of a unique research method of the scientist, the essence of which was to combine sinology with sociology. Thus, the first author’s work organically combined the history of China with the life of ancient Chinese society. Particular attention was paid to the study of life, mentality, marital relations, social stratification, etc. The second monograph is basically a thorough study of ancient China religious peculiarities, the study of the role of rites and rituals in the life of ancient society. It also describes classical schools of Chinese philosophy. In particular, the scientist analyzed philosophical views of two most prominent representatives – Confucius and Lao-Tzu (Granet, 1999).

Among other outstanding sinologists of the early 20th century are Paul Pelliot and Henri Paul Gaston Maspero. Thus, Paul Pelliot, a professor of the College de France, was engaged in researching the history of ancient China, the history of Taoism and Buddhism, and also studied the role of other religions in Chinese society (Kiktenko, 2017, p. 48).

Henri Paul Gaston Maspero became a famous sinologist of the first half of the 20th century. As well as Paul Pelliot, Maspero’s field of interest concerned the research of traditional Chinese studies. In the scientific world, Maspero is considered to be the first researcher of Taoism. His scientific achievements helped to expand the field of sinological science, including such components as the study of Buddhism, Taoism, art, mythology, and the history of science (Maspero, 1950).

It is worth noting, that so-called Paris type of sinology prevailed in the powerful French Sinology School until the middle of the 20th century, which later went beyond the country and spread to the national scientific schools of England, Germany, and Great Britain, significantly strengthening the country’s position as a center for the development of Chinese studies. French sinologists concentrated their efforts on the study of history, culture, philosophy, language and literature, gradually secularizing the scientific achievements of their predecessors, finally turning Chinese studies into a secular science.

The next period in the development of Chinese studies in France began in the 1950s–1960s. At that time sinology departments appeared in leading French universities in such cities as Paris, Nice, Lyon and Bordeaux. The largest centers for the study of China were the National Institute of Oriental Languages and Civilizations, the Chinese section of the Institute of East Asia at the University of Paris, as well as the Center for Far Eastern Studies and more. In addition, Chinese has been implemented for study in more than 20 lyceums and colleges across the country.

At the same time, French academic circles began to think about a crisis in the study of sinology, especially history, and a low level of future sinologists training in French academic institutions. For example, the Aix-Marseille University professor Christian Henriot, after analyzing the curricula of academic institutions, concluded that

despite certain positive steps, in particular, the involvement of a wide range of foreign students (Chinese, Taiwanese, Italian and Canadian) and the use of original approaches to teaching, the study of certain subjects related to Chinese studies, especially history, in the first third of the 21st century suffered a complete failure, as this field remains too institutionalized (almost all centers of Chinese studies are located in Paris) and marginal (Henriot, 2020). That is why the leadership in the study of sinology went over to the United States of America, Great Britain and China itself.

Despite this fact, the historical evolution of French sinology continues. The modern period of French Chinese studies development is characterized by the creation of new methodological technologies for conducting research, which undoubtedly became the driving force for the formation of various scientific approaches and directions of modern sinology study. The interdisciplinary approach plays a leading role in scientific research. Thus, the majority of researchers turn their attention to the analysis of modern China development through the prism of humanities and exact sciences.

A characteristic feature of modern French sinology is a combination of historical research with their philosophical understanding. The fundamental scientific work “History of Chinese Civilization” by Jacques Gernet (1921–2018), one of the famous sinologists of nowadays, is an example of such an approach. The researcher, applying modern methodological traditions, combined thorough factual material with its philosophical interpretation (Gernet, 1995). The work is characterized by a vast amount of revolutionary views on the history and culture of China. In particular, the scientist, contrary to a widespread statement among scientists about the isolation of Chinese civilization from the surrounding world, made a conclusion that the latter did not develop in isolation from other civilizations. On the contrary, for an objective understanding the essence of China, it is necessary to investigate and study it, starting from the ancient period, in relation to other civilizations of Asia, which have undoubtedly been influenced by it for a long period.

French philosopher Francois Jullien (born in 1951) can also be considered one of the most prominent sinologists of our time. His works are full of philosophical reflections on the relationship between Chinese and European cultures. The scientist pays attention to the study of such aspects as ethics, aesthetics, and philosophy of thinking. One of the most famous scientific works of the author is the historical and philosophical study named “Detour and Access: Strategies of Meaning in China and Greece”, in which the author compared philosophical traditions of two civilizations – Greek and Chinese, claiming that the Greeks went a long historical path formation of their political, legal, cultural and philosophical systems, while for the Chinese this path was marked by various allegories, evasions and the ability to read between the lines (Jullien, 2000).

The application of the interdisciplinary approach, namely a combination of humanities and exact sciences, is demonstrated by the scientific research of French sinologists Karine Chemla and Catherine Jami. The first one is a well-known French historian of mathematics and sinologist, the head of research at the National Center for Scientific Research, a general editor of several fundamental collective works on the

history of mathematics. One of them, “The History of Mathematical Proof in Ancient Traditions” (Chemla, 2012), is an excursion into the past of the history of mathematics in Asian countries. One of the sections devoted to the development of mathematical knowledge in China is authored by Chemla. In general, this work was comprehended rather discreetly by the scientific community – some readers called it a new page in depicting the connections between mathematics and various cultures in the context of which it was practiced, while others, on the contrary, assumed the study to be not devoid of sensationalism – which, in our opinion, is the evidence of French sinology loss of leading positions in the world.

Catherine Jami is another French sinologist specializing in the history of Chinese mathematics. Her scientific interests are quite wide, in particular, the history of mathematical knowledge in both medieval China and 20th century China. Jami is the author of scientific publications in which the so-called Western influence (primarily Jesuit) on the formation of Chinese science is analyzed (Jami, 2014, 2019). She is also a co-editor of many edited volumes and a guest editor of special journal issues.

The combination of history and sociology became characteristic of another modern French sinologist’s works, the University of Paris professor Gilles Guiheux. The evolution of the Chinese society social structure during the transitional period through the prism of historical events is the subject of the scientist’s study. Guiheux’s research interests are related to the study of the influence of the private property arising on the emergence of new social strata in China (Guiheux, 2014). The territorial boundaries of the research reach the borders of mainland China, starting from Zhejiang province, on one hand, and Shanghai, on the other. A separate area of Guiheux’s research is considered to be Taiwan, a country with limited international recognition. One of the monographs “Les Grands Entrepreneurs privés à Taiwan” is devoted to the analysis of the successful business conduct by great entrepreneurs of the island state. The researcher uses historical context to analyze the main reasons for the economic success of the Taiwanese in modern globalized world (Guiheux, 2002).

The representatives of the intellectual approach to the study of history are French sinologists Christian Henriot and Marianne Bastid-Bruguière. They work in the field of intellectual history full of existentialism. Christian Henriot’s research interests are focused on the history of modern China and the history of Chinese elites. His most famous works “Prostitution and sexuality in Shanghai” (Henriot, 2001) and “Scythe and the City: A Social History of Death in Shanghai” (Henriot, 2016) analyze such problems in the life of Chinese society as prostitution and high mortality of the population. In order to improve and modernize research methods, the scientist also created a number of digital platforms such as “Virtual Cities”, “Virtual Shanghai”, “Digital South Asian Library”, etc., which, in his opinion, should help return public interest in the study of sinology.

The President of the Academy of Humanities and Political Sciences, Marianne Bastid-Bruguière, is engaged in researching the period before and after the Xinhai Revolution in 1911 (from the end of the 19th century to the beginning of the 20th century) and is the author of a large number of monographs and publications. One of

the professor's latest works is devoted to the study of the cultural dialogue between China and Europe (Bastid-Bruguière, 2022).

In addition, Marianne Bastid-Bruguière also focused her attention on the analysis of modern trends in France sinology development (Bastid-Bruguière, 2008), researching the level of teaching of Chinese studies disciplines in French academic institutions, the functioning of research centers and the implementation of their programs, etc. This enabled her to respond in a timely manner to all the challenges modern French sinology faces and become one of five most outstanding Chinese historians of France in the 21st century.

Conclusions.

Thus, having studied the historical development of sinology in the 13th–21st centuries, we can conclude that this science has undergone a long evolution with its birth, flourishing and stagnation becoming the main components. The birth or protosinological stage lasted almost five centuries (13th–18th centuries) and was characterized by the work of French Jesuit monks at the Chinese Emperors' court, the first translations of Chinese original sources, cartographic work, etc. The flourishing period (19th – first half of 20th century) marked the transformation of missionary sinology into academic one, the secularization of scientific knowledge, the penetration of Chinese studies into the educational programs of academic institutions in France, the appearance of a galaxy of talented sinological scientists, due to whose research the Parisian type of sinology spread among the national scientific schools in different countries all over the world. The period of stagnation coincides with contemporaneity and denotes the loss of primacy of French sinologists, the appearance of various disparities in the study of particular components of sinology, especially history (noted by French scientists themselves), the relocation of scientific sinological centers to the USA, Great Britain and China itself, as well as further searches of new methodological approaches by modern Chinese scholars and the transformation of sinology into a multidisciplinary science that combines various aspects of the humanities and exact sciences.

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Розвиток французької синології (13–21 століття): історичний аспект

Анотація. В історії розвитку синологічних вчень окреме місце займає французька синологія. Саме Франція стала найпершою країною, в якій відбулася трансформація місіонерської синології, що була поширена серед обмеженого кола дослідників (в основному у релігійному середовищі) в академічну наукову дисципліну, яку вже на професійному рівні викладали та вивчали у вищих закладах освіти. Саме паризький тип синології тривалий час домінував у всьому світі, включаючи такі потужні центри китаєзнавства як Німеччина, Великобританія, США, й власне сам Китай. Проведений історіографічний аналіз теми дозволяє говорити про недостатнє висвітлення вітчизняними дослідниками еволюції історичного розвитку французької синології як цілісного процесу, котрий тривав майже 800 років. Даний факт спонукав авторів до розкриття зазначеної теми. Мета статті – дослідити історичний розвиток французької синології протягом 13–21 століть. У ході роботи було використано як загальнонаукові методи, так і спеціальні, серед яких пріоритетне місце зайняли історичний, хронологічний та проблемно-тематичний. Також було застосовано аналітичний метод та методи групування і типологізації, що дозволило подати матеріал логічно завершеним. Для формування цілісної картини розвитку синології у Франції авторами було виокремлено та проаналізовано три історичні періоди, що охопили всю історію розвитку китаєзнавства, починаючи від зародження та розквіту до процесу стагнації. Так, у часових межах першого періоду досліджено процес накопичення своєрідної наукової бази знань про Китай, а також розвиток місіонерської синології та доведено, що саме вона стала своєрідним містком між протосинологічним етапом та академічною синологією, яка секуляризувавши здобутки попередників у 19 ст. перетворилася на наукову університетську дисципліну. У часових межах другого періоду проаналізовано наукові здобутки цілої плеяди французьких науковців а саме, Едуарда Шаванна, Марселя Гране, Анрі Поля Гастона Масперо тощо та зроблено висновок, що тогочасна синологічна школа у Франції перебувала на піку свого розвитку, а погляди її представників стали пріоритетними серед синологів світу. Щодо третього періоду, авторами висловлено думку про те, що сучасна французька китаїстика втратила лідируючі позиції в науковому світі, а пошуки новітніх методологічних підходів та методів (насамперед мультидисциплінарних з використанням цифрових технологій) є передусім спробою досягти паритетного становища із провідними центрами синології. Фактологічний матеріал дослідження може бути залучений для подальшого вивчення історії розвитку синології, а також для написання узагальнюючих праць із китаєзнавства, до читання лекційних курсів, спецкурсів та спецсемініарів.

Ключові слова: Китай; історія науки; протосинологія; місіонерська синологія; академічна синологія; мультидисциплінарний підхід

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Science and comics: from popularization to the discipline of Comics Studies

Abstract. *Modern scientific communication traditionally uses visual narratives, such as comics, for education, presentation of scientific achievements to a mass audience, and as an object of research. The article offers a three-level characterization of the interaction of comic culture and science in a diachronic aspect. Attention is focused not only on the chronological stages of these intersections, the expression of the specifics of the interaction is offered against the background of scientific and public discussions that accompany the comics–science dialogue to this day. Within the framework of the first stage (the appearance and distribution of popular science and educational comics), the characteristics of comics content necessary for the different genesis are highlighted: documentary storytelling, educational practices of learning through drawing, active cooperation with well-known companies and institutions, informativeness and empathic involvement of the young reader in a heroico-romantic narrative of scientific discoveries and mastering nature. With the intensification of interdisciplinary approaches (the second stage), comics are increasingly involved in presenting scientific results within the most diverse fields. Comics-based research is becoming an interdisciplinary method and a widespread practical area with the corresponding formation of scientific tools (applied comics, data comics), forms of interdisciplinary interaction (graphic medicine, ethnography, narrative geography, urban comics, comics journalism, etc.), and scientific publications (“The Comics Grid: Journal of Comics Scholarship”, “Sequentials”). The national format of comics-based research is presented on the example of Ukrainian comics projects (historical, feminist comics). In the genesis of development, Comics Studies have gone from a field of research to disciplinary definitions. In the creation of the metadiscourse of the*



scientific direction (the third stage), the authors focused on scientific discussions, the formation of academic directions and approaches, and markers of disciplinary self-identification. Emphasis is placed on the unique phenomenon of the simultaneous concordance of various stages of the dialogue between comics and science, on the prolonged replication of successful inventions into modern experience, and the active testing of known narratives at new levels of a scientific presentation.

Keywords: *scientific communication; applied comics; comics-based research; comics studies*

Introduction.

The interaction between the art of sequential images and science has a long history in developing illustrative techniques and auxiliary means of presenting the material. With the spread of scientific comics in the middle of the 20th century, their introduction into educational practices, and popular science discourse, the graphic narrative lost its stigmatized status, combining entertainment and motivation for learning as an accessible mass form of scientific communication (Tatalovic, 2009).

Modern scientific communication increasingly uses visual techniques for popularizing knowledge and scientific discoveries (Dunst, Laubrock, & Wildfeuer, 2018; Jonsson & Grafström, 2021; Peterle, 2021; Forde, 2022). Lists of comics suitable for use in the natural sciences, social sciences, and humanities are included in university curricula and syllabi (see, for example, <http://comicbooksyllabus.com>). The relevance and demand of such techniques are illustrated by new requests from the audience, especially the young. The familiar and traditional form of knowledge popularization in the science–comics dialogue acquired unique qualities. Today, the use of comics as a tool for visualizing scientific results has rooted in the practice of using graphic narratives in archeology (Kamash, Soar, & Van Broeck, 2022), biology (Hosler & Boomer, 2011), art history (Thornborrow & Gosse, 2020; Chang, 2021), architecture and urban planning (Cancellieri & Peterle, 2021), pedagogy (LeBlanc & Irwin, 2018; Alie, Ilhamdi, & Saputra, 2021), journalism (Weber & Rall, 2017; Hudoshnyk, 2020), in mathematics (Puput, Ahmadi, & Rochmad, 2021), computer sciences (Augereau, Iwata, & Kise, 2018) and interdisciplinary methods (Farinella, 2018; McNicol, 2019; Jacobs, 2019; Kuttner, Weaver-Hightower, & Sousanis, 2020).

In turn, the study of comics from an interdisciplinary space in the last decade reaches the level of forming a new subject field – Comics Studies, with appropriate academic markers and standards (scientific publications, dictionaries, monographs, international conferences, dissertations, and university courses and doctoral programs). The history of the formation of certain areas of science and art is colorful, changeable and, most importantly, extended over time. It is all the more relevant for a researcher to see the birth of a new field, the transition from quantitative research to the formation of qualitative definitions of a new discipline. Comics studies build concepts of self-determination and the history of its formation in complex discussions (Domsch, Hassler-Forest, & Vanderbeke, 2018; Aldama, 2020; Hatfield & Beaty, 2020; Fawaz, Whaley, & Streeby, 2021; Cour, Grennan, Spanjers, & Nature, 2022).

We identified three stages in the interaction of science and comics. We note right away that in chronological space they do not successively replace one another: the communication feature of consists in the active use of the newest and already invented forms, in the almost unique concordance of creative discoveries and their scientific research, in the active participation of the audience as a powerful actor in the development and comic culture, and its study. As a result, comic artists become the first comic researchers and popularizers, and the scientific space of the industry is actively open to author explorations and the comic fan community.

The first stage (1941 – until today) of the use of comics as an illustrative and didactic form of demonstration of scientific results (popular science, educational, educational comics).

The second stage (the 1970s – until today) – is an interdisciplinary research and the latest practices of comics-based research, the spread of applied comics.

The third stage (2010 – until today) is the formation and self-identification of the scientific field of graphic narrative research (Comics Studies).

Therefore, the *purpose* of this article is to review the history of the intersection of science and comics, including in the Ukrainian scientific space, in the areas of the popularization of science, the spread of comics-based research as a continuation of the interdisciplinary approach in comics criticism; formation of a new discipline of Comics Studies. To illustrate these stages, we choose series, comic books, and cycles that contain important ones characteristics for further genesis. Due to the powerful discussion context of the stated topic, we consider it appropriate to at least outline the subjects of these academic, pedagogical, and public discussions.

Stage I. Education, popular science and comics.

The active spread of popular science series, for example in the USA, coincided with the beginning of the Second World War and was determined by the urgent need to create a heroic narrative in which real people, not mythological ones, win.

Documentary, mastered by graphic storytelling, became extremely popular and in demand, and the need to create accessible educational content for a certain time removed a rather tough discussion in society about the quality of the comic genre. Series “True Comics” (1941–1950), “Real Heroes” (1941–1946), “Real Life Comics” (1941–1952) rivaled readers in terms of audience popular superhero comics and set a goal in difficult wartime to provide examples of exceptional courage not only at the front but also in all spheres of life. A modified Byronic quote about truth being stranger than fiction became the epigraph of “True Comics”: *TRUTH is strange and a thousand times more thrilling than FICTION*. It was the first edition devoted to real heroes of history, science, politics, military affairs, medicine, sports, etc. The Editorial Board monitored the selection of personalities and topics, and historians, educators, and sociologists worked as consultants on the issues of the series. This meticulous attention to educational comics was related to the public debate in American society about the advisability of introducing children to comics (S. North A National Disgrace. *Chicago Daily News*. May 28, 1940), so to some extent, popular science became the ‘savior’ of the comic industry. And the documentary of the first popular series was later extended

by the powerful direction of documentary comics with the appropriate typology (military, social, environmental, reportage) and research methodology (Chute, 2016; Mickwitz, 2016; Schmid, 2021).

The active development of educational, popular science, and educational comics did not cancel the confrontation between high and low literature (comics included), which only intensified after the war. In 1954, Fredric Wertham's book "Seduction of the Innocent" was published, which argued that comic books contribute to juvenile delinquency. A lively debate in the press and communities, at parent-teacher conferences and in schools culminated in Congressional hearings and the passage of the Comics Code Authority. The Code became the first manifestation of self-regulation of the comic industry in accordance with social requirements. This form of political compromise through compliance with content standards was intended to promote a normative culture and consolidate the social authority and legitimacy of comics as such (Deverell, 2021; Greenberg, 2022). According to researcher R. Deverell, ironically, The Comics Code gave protection to authors who saw comics as political art rather than entertainment:

"The writers of these stories wanted to reach their readers as individuals who could each find their own meaning in the stories rather than produce a product that offered the same generic entertainment to anyone who purchased it at the newsstand. In doing so, they sought to elevate their own status as artists, escaping from "low culture" and joining the ranks of "high culture" (Deverell, 2021, p. 2).

Despite devastating criticism and protests against the Comics Code Authority, it was finally ignored by the producers and the cancellation of the famous Comics Code seal only happened in 2011.

The authors of the "Classics Illustrated" series from the Gilberton Company (1941–1969), which had nationwide distribution and actively used the comic as an *educational tool* to popularize the reading of classic works of world literature, also tried to promote the spread of knowledge and attract children to reading. Innovative approaches were notable: the creation of an original adaptive scenario (this series differed from the classic illustrations of literary works), the universally recognizable stylistic unity of the cover design, additional spin-off "Classics Illustrated Junior" (1953), "Classics Illustrated Special Issue" (1955), and "The World Around Us" (1958).

"The World Around Us" series (1958–1961) became one of the first systematic educational and popular projects. Each issue was devoted to a separate direction: legislation, communication, the army, the FBI, the Civil War, space, great discoveries, etc. The creation of a holistic view of various aspects of human activity, politics, and society has become a hallmark of the entire series. The compositional structure of individual issues, where the history of discoveries was illustrated by real events in the development of the industry and biographical stories, also fundamentally differed from the traditional encyclopedic presentation. Each story was based on factual material and was presented in the shortest possible, but plot-complete form. In this way, scientific discoveries were connected with the development of progress and human actions at the same time. A military man, a pioneer, a scientist, and a test pilot became the heroes of

whole industry narratives, science from the unknown and the unknown became humanized, alive, and close to the reader. The plot highlighted everyday life with unusual events and the romance of exploring new horizons of knowledge: from the history of the Crusades and medicine to the exploration of outer space and the classified work of the FBI.

Let us add that the educational comic and the use of the art of sequential images in pedagogy and education is perhaps the richest direction in scientific research (Farinella, 2018; LeBlanc & Irwin, 2018; Puput, Ahmadi, & Rochmad, 2021; Alie, Ilhamdi, & Saputra, 2021), but the pedagogical system of art-integrated education, spread at the state level, for example in the USA and India, actively includes comics in STEM education programs today.

Comics were also ordered by large companies. Thus, the series “Adventures in Electricity” (1946–1950) was created for the General Electric Company, which popularized the history of the formation, development, and future of electricity, and introduced young readers to the everyday experience of using light. The habituation of scientific discoveries continued in 1947–1959 with “Adventures in Science” series with a greater thematic variation: the history of aircraft construction, the development of atomic energy, engineering, stories about the creation of rockets, and space exploration. There are clips of interviews with famous scientists, and more and more often pictures of the future are placed on the pages of comics, where technologies radically change medicine, agriculture, industry, technology, and life in general. A cluster of historical comics (“Adventure into the Past”, 1949; “Real Life Comics”) easily combined national and world history and time travel became a common method of immersion in the familiar symbolic details of the world of the past. The plot and compositional innovations became noteworthy: the dialogic nature of the story, the presence of a hero, traditional for educational comics, with whom the young reader could easily associate himself. In the non-fiction genre, four issues of “Marvels of Science” were created, where reality, fiction, and creative imagination were combined within one comic: the exploration of the depths of the sea alongside the biography of Niels Bohr, the experiences of creating prototypes of a jet plane and hunting a rhinoceros (No. 1, 1946).

As a mediator and mediator of scientific ideas, today comics are part of a powerful publishing industry, a field of experimental educational programs, commercial projects, and author's initiatives. This direction has an additional vector: the dissemination of the results of the activities of scientific institutions, international organizations, and ministries to a mass (including youth) audience. In the typology of this huge content, we will name the most significant ones:

- a cycle of graphic histories “Astrobiology: The Story of our Search for Life in the Universe” (2010–2022) was created by order of NACA (<https://astrobiology.nasa.gov/resources/graphic-histories/>);

- a series was created in cooperation between NACA and the Japan Aerospace Exploration Agency “Raindrop Tales: GPM Meets Mizu-Chan” (2014) (<https://gpm.nasa.gov/education/comics>);

- The European Environment Agency popularized its activities in a cycle “Eco

Agent's website" (2007–2008);

- comics commissioned by the Scientific Committee On Solar-Terrestrial Physics (SCOSTEP) were devoted to several topics in Solar-Terrestrial Physics and were translated into 14 languages (<https://scostep.org/space-science-comic-books/>);

- half a million subscribers and 200 comics contain the resource phdcomics.com, which tells about the life and scientific research of graduate students and young scientists.

Even the respected "The Lancet" drew attention to the empathy and informativeness of the comics "have long been part of the visual culture of medicine: a strength of comics is that they present this information through engaging visual storytelling that can place the reader into the experience and contextualize the impact of contagion" (Callender, Obuobi, Czerwicz, & Williams, 2020).

The comics has remained a means of popularization to this day, actively combining education, entertainment, accessibility, and recognizability of the main characters of the series. Of course, the audience of such works is aimed mostly children and adolescents, and it has its own scientific methods of analysis and measures of effectiveness with corresponding caveats and cognitive consequences (Jee & Anggoro, 2012). But especially children and teenagers, future scientists, engineers, writers, technologists, researchers and those who were simply indifferent to new discoveries fell under the charm of comics and replenished the baggage of scientific knowledge by reading popular comic series. In the lecture "Science Comics Can Save the World!" the famous scientist and author of science comics Dr. Jay Hosler noted that it is children who are not afraid to combine curiosity, creativity, and stories that will be able to save the future. "And comics will help them in this" (Hosler, 2018).

Summarizing this first stage, we note: popular science and educational comics clearly defined their audience and visualized the goal of spreading knowledge through a format familiar to teenagers, compositional and stylistic simplifications, and a clear plot. In them, technical, natural, and historical discoveries easily fit into the romance of travel (even at times) and adventure. This potential has remained in demand at different times and in different industries and countries (Tatalovic, 2009). At this stage, the comic book acquired a new meaning in mass perception as well – its powerful educational potential made it possible to see in it the prospects not only of expanding knowledge for teenage audiences but also in scientific communication in general.

Stage II. Interdisciplinary discourses and practices: comics as a tool for scientific research.

The mass perception of comic technique as a means of popularization made it possible to bring comics into the space of academic science. Today we can talk about the stratification of this process into separate directions: the study of comics as a separate field and even a discipline and the use of comics as a tool for presenting scientific research, more broadly, for the development of scientific communication (see the scheme in Figure 1).

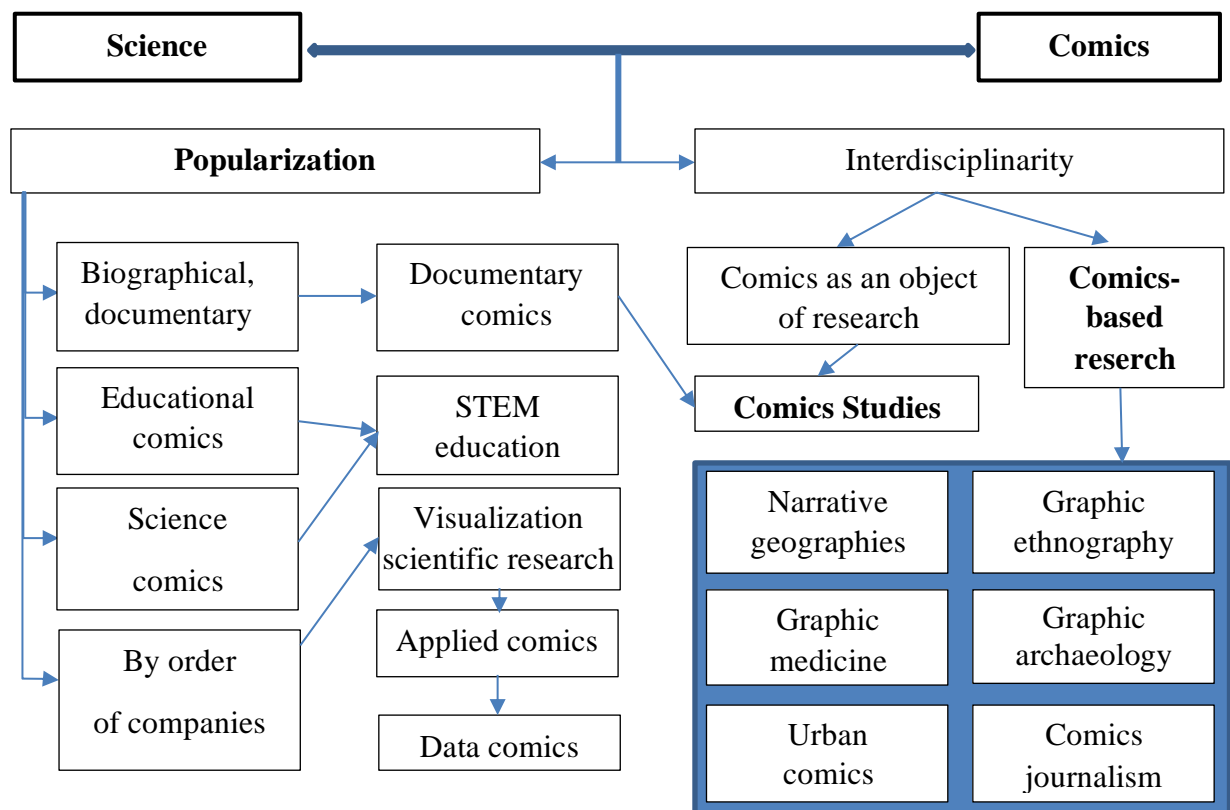


Figure 1. Scheme. Structure of interaction between science and comics.

The phenomenological nature of comics is the subject of research by the world scientific community, and the attempt to avoid “professional blinders”, establishing new channels of scientific communication (Jonsson & Grafström, 2021) is rapidly expanding the space of interfering diffusion forms and interdisciplinary innovations. In 2015, the interdisciplinary laboratory of the Humboldt University of Berlin organized the international symposium “Science meets Comics”. The unanimous opinion of researchers from various fields about comics as a universal means of communication and presentation of global problems was indicative (Leinfelder, Hamann, Kirstein, & Schleunitz, 2016).

Today, a new interdisciplinary area of methodological practice – comics-based research (CBR) – is proposed for discussion, and rather, for legitimization. The definition of CBR as an interdisciplinary methodology and a new practice field was proposed by American researchers P. Kuttner, M. Weaver-Hightower, and N. Souzanis in 2020: “CBR is neither a research methodology (a broad conceptualization of how to approach research) nor a method (a specific practice conducted during research)” (Kuttner, Weaver-Hightower, & Souzanis, 2020). The methodology went from the analysis of the cultural, semiotic, and communicative nature of the comic to the understanding and effective use of it in various fields.

We have already analyzed various features of using CRB as a method of additional visualization of research results and the common practice of collaboration between scientists and comic artists (Hudoshnyk, 2022a). British researcher S. McNicol suggests using comic techniques at various stages of research: documents

in the form of comics (information sheet, summary sheet, questionnaire); an interview based on a comic drawn by the participant; creation of a comic based on an interview with a participant; discussion of different comic book interpretations (McNicol, 2019). The scientist demonstrates the practices of embodiment in the project “Research: Graphic Lives” from Manchester Metropolitan University involves graphic narratives in “arts-based research methods to explore social issues and well-being with a focus on community narratives and individuals' stories” (Research: graphic lives, 2017).

Such approaches are actively used in a wide variety of modern projects by universities, art schools, libraries and public organizations. For example, scientists at Newcastle University demonstrate the effectiveness of using comics as a presentation tool for research and creative student initiatives, when developing thematic sites, supporting materials for lessons or performances (Newcastle Science Comics: “Gertrude Bell Comics”; “Freedom City Comics”). Interdisciplinary explorations are conducted in parallel with making comics as a way to disseminate research. “Newcastle Science Comics” projects on the creation of scientific comics were the result of joint work with museums, libraries, and galleries. The resource “Applied Comics” (appliedcomicsetc.com/) offers collective cooperation academics, public figures and comics artists with integrated comic projects taking into account the target audience (“Strike comics”; “Learning framework: Freedom City Comics”, 2018) (Wisocki, Murphy, & Murphy, 2021). The initiator and active participant of the association Lydia Wysocki (2022) in the methodology of using comics as a research is based on multimodal and sequential (multimodal and sequential) methods: planning; data elicitation, collection, transcription and analysis; dissemination and engagement.

Data Comics, represented by a collaboration of universities in Canada, the United States and the United Kingdom, offers a proven algorithm for cooperation between researchers and comic artists in creating presentations and scientific reports (datacomics.github.io).

CBR is growing fastest in industries where “narrative construction is a core practice” (Kuttner, Weaver-Hightower, & Sousanis, 2020). The study of narratives is a powerful tool for broadening ideas about the possibilities and criteria of CBR in general, and the peculiarities of national narratives in particular (Chang, 2021).

CBR methodologies within individual industries are highlighted. Thus, *graphic medicine* is defined as an interdisciplinary approach to telling personal stories about illness and health through the use of comics, and according to the founders, it is “a movement for change that challenges the prevailing methods of health care, offering a broader view of medicine, illness, disability, and care” (The Graphic Medicine Manifesto, 2015). The direction is represented by a very active international community (see graphicmedicine.org), a powerful corpus of medical comics and pathographies (Wegner, 2020), annual conferences, educational modules, master's programs of medical educational institutions in Europe, the USA, Canada, Japan within courses in narrative medicine and Health Humanities. The educational and media activity of the community is impressive: cooperation with well-known publications (the weekly comics “Sick Notes” for “The Guardian” was drawn by Ian Williams, the founder of the direction), creation of own projects with ready-made comics for training

medical workers, for social and educational campaigns (artibiotics.com). The pandemic has actualized this cluster of graphic narratives (see, for example, “Comics for Good” resource, “The Moment” series by Singaporean artist Sonya Liu, “The Vitals: True Nurse Stories” by Marvel Comics, etc.).

Narrative geographies offer the dissemination of geo humanities and the creation of comics as a graphic practice of conducting research. An example of such geographical narratives was the comic anthology “Quartieri: Viaggio al Centro delle periferie italiane” about five districts of Italian cities. Geographical and ethnographic field research is embodied in the direction of Graphic mobilities, Urban comics (Peterle, 2021; Cancellieri & Peterle, 2021), and graphic ethnography (Forde, 2022).

The combination of *archeology and comics* is today presented in the directions of transmedia archeology (Scolari, Bertetti, & Freeman, 2014), and educational methods (Kamash, Soar, & Van Broeck, 2022; Swogger, 2022). The involvement of CBR is demonstrated both by well-known researchers (“Shovel Bum: Comix of Archaeological Field Life”, 2004) and by the authors of a popular scientific graphic novel for “National Geographic” (A. Maleev and M. Furlong “The Killing of the Iceman”, 2011).

In the modern dictionary “Key terms in comics studies”, the presented varieties are called Applied Comics: “*Applied comics are comics with a specific job to do. They communicate information to a target AUDIENCE, a goal that shapes choices made throughout the comics-making process and differs from a general category of non-fiction comics. Applied comics are typically made as a COLLABORATION between subject specialist(s) and comics CREATOR(S), although one person might take on both roles*” (Cour et al., 2021, pp. 20–21).

The effectiveness of the interaction of scientific fields and comics was based on its main qualities: ease of perception due to the simultaneous involvement of familiar and new discourses; narrativity – graphic storytelling and narrative style are very common in the information space; metaphorical thinking as a cognitive tool (Farinella, 2018; Kuttner, Weaver-Hightower, & Sousanis, 2020).

A special cluster in the indicated direction was the use of CBR when examining the comics themselves. It should be said that such an unusual tradition is based on the uniqueness of the constant involvement of comic book authors in the research activity. Scott McCloud, a well-known master of non-standard techniques and approaches, published “Understanding Comics: The Invisible Art” in 1993, there by starting the tradition of talking about comics in his own language. In 2010, Jason Helms was the first to defend a scholarly work involving comics techniques (Helms, 2010). In 2014, Nick Sousanis completed the dissertation “Unflattening” at Columbia University. The unusual thing was that all 132 pages were comic panels – the author saw a special metaphorical in this form of argumentation of the main thesis of his work about the importance of visual thinking in teaching and learning (Sousanis, 2020; Sohini, 2022).

In July 2014 “Critical Inquiry” creates a unique “Comics and Media” issue, including scholarly texts, an interview with Art Spiegelman, a panel discussion with Phoebe Gloeckner, Justin Green, Aline Kominsky-Crumb, and Carol Tyler, and comic pages by Alison Bechdel, Lynda Barry, Seth, and Phoebe Gloeckner. The number itself

in digital form became the first to analyze the comic together with the comic artists in the form of a graphic anthology. In 2015, the Special issue of Digital Humanities Quarterly “Comics as Scholarship” presents an issue already fully adapted to digital requirements, boldly experimenting both with comic style in the presentation of articles and outlining the problems of digital scientific communication within CBR.

The spread of the use of CBR in scientific practice is also confirmed by the appearance of new types of scientific journals. Corresponding to the logic of their research object, they offer material with the active involvement of drawings, comic panels, strips, and articles in the form of separate comics and cycles. “The Comics Grid: Journal of Comics Scholarship” has existed as a comics studies blog since 2010, and today, despite the unusual form, is an academic publication with appropriate standards. “Sequential” magazine publishes research in comic format on a variety of issues: art reviews, analysis of postmodern reality, polysemy, queerness, history of materiality, etc.

The practices of combining comics and science in the Ukrainian space are mostly related to the visualization of encyclopedic projects (“Illustrated history of the independence of Ukraine”, “Constitution in comic” by the Kapranov brothers), comic book adaptations of works of classical Ukrainian literature (“Classic comics” series by the Grani-T), creating scientific comics (a series of books “Science comic” from Ranok publishing house) and a powerful market of translated scientific popular literature. At the same time, one cannot fail to note the bright projects of 2021–2022. Among them is “Defense of Zamostia. The Legend of the Shovel” (2021) – the first historical comics created on the initiative of the Ukrainian Institute of National Memory. As in most historical comics, interesting facts about the described events, excerpts from documentary chronicles, and biographies of the actors are presented at the end of “Defense of Zamostya”. Combining factual reliability, artistic fiction, and fantasy, despite the controversy, is becoming a common practice in Ukrainian historical-documentary and military comics (Hudoshnyk, 2022). In 2022, the work of young Ukrainian researchers and artists “A Brief History of Ukrainian Feminism” (Yabchenko, 2022) was published, which to some extent broke the CBR tradition of using comics only as a means of visualizing content. Despite a certain schematic and the color monotony inherent in social and documentary comics, the authors actively experiment with the plot, figurative symbols, archival inserts, and historical time. Thanks to the uniqueness of the comic chronotope, the authors manage to tell the story through life actions, dialogues, and gender myths and clichés familiar to the mass reader. Dynamic and full of facts, a short excursion into the history of Ukrainian feminism successfully demonstrates the other side of CBR: the comic has its own logic and meaningful structure. Not taking it into account means simultaneously losing the significant potential of comic storytelling and “meaning-making in research” (Thornborrow & Gosse, 2020, p. 116).

Stage III. From research field to discipline: the genesis of Comics Studies.

In the genesis of scientific approaches to the analysis of comics as an object of research, cultural studies turned out to be the most friendly to the new genre, which is

why the list of founders of interest in the new art form looks so diverse. In 1923, Gilbert Seldes, in his book “The Seven Lively Arts”, names Slapstick Moving Pictures, Comic Strips, Revues, Musical Comedy, Columns, Slang Humor, Popular Songs, and Vaudeville as the antithesis of classical arts. In the section “The ‘Vulgar’ Comic Strip”, the author writes with irony: “Of all the lively arts the Comic Strip is the most despised, and with the exception of the movies it is the most popular” (Seldes, 1923, p. 213). But the definition of comics as the 9th art form, made by the famous French critic Claude Beylie based on the analysis of the European comic strip *Bande dessinée* (Beylie, 1964), has become popular today. 1964 also dates to the books of famous philosophers Roland Gérard Barthes (essay “Rhetoric of the Image”) and Umberto Eco (“Apocalittici e integrati”), which started the direction of research into the semiotics of comics.

The scientific understanding of the comic chronologically coincided with the flowering of the comic itself “the art of sequential images” in the late 1930s. Thus, in 1942, Paul Cassidy defended the first scientific paper “An Approach to the Profession of the Comic Strip Cartooning Based Upon an Analytical Survey of Current Trends and Personal Experiences” at the University of Wisconsin. The study was based on an overview of the practices and methods of the comics industry, but most interestingly, it included the personal experience of the author and the results of a survey of the most famous masters of the industry at the time (Ricca, 2014).

Traditionally, the first collection of scientific articles on comics is considered to be a special issue of the “Journal of Educational Sociology” (1944, Vol. 18, No. 4), the section of which was devoted to the use of comics as a teaching method. Despite the guiding idea to study comics as a “great new medium of communication and social influence” (Zorbaugh, 1949), for many years the subject of systematic the comic did not become of scientific interest due to academic snobbery and the “unseriousness” of the research object: *“While visual narratives were embraced in other cultural environments – the French bandes dessinées or the Japanese manga – the obvious popularity of early comics raised suspicion rather than academic interest, and scholarly attention to what French critics have long referred to as the ‘ninth art’ emerged very slowly”* (Domsch, Hassler-Forest, & Vanderbeke, 2021).

A powerful explosion of scientific interest was caused by several circumstances. The spread in the second half of the 20th century in the countries of Western Europe of graphic novels, l'album, comic book made it possible to include comics first in the “legitimate cultural practice of middle-class reading” (Gabilliet, 2005), and due to the “respectability” of the analysis of the novel structure – in the literary, and then multidisciplinary practices. The appearance of William Erwin Eisner's comics, first of all “A Contract with God” (1978), which is called the first graphic novel, became iconic for the direction. Harvey Pekar's “American Splendor” series (1976–2008) pioneered the trend of documentary comics and autobiographical narrative in comics culture. Art Spiegelman's Pulitzer Prize-winning novel “Mouse” (1992) was a milestone in the recognition of comics' right to represent the most complex political and social issues. A separate direction of comic journalism dates back to 1993 with the publication of Joe Sacco's graphic novel “Palestine” in the reportage genre.

The second reason for the active interest in comics was the superheroic film industry, which is exceptional in terms of audience, profits¹ and global distribution: “widespread interest in heroic narratives and increasingly diverse representations of heroic power in comic media remains an enduring impulse over decades of cultural production and across multiple visual platforms” (Cour et al., 2021). It actualized both the interest in already known comics and contributed to the intensification of the development of national comic cultures and publishing strategies (including in Ukraine). The first attempts to form the academic discourse of Comics Studies as a field of inquiry date back to the early 2000s: specialized publications, electronic library archives, inter-university thematic international conferences, university special courses, and educational programs appear (Cour et al., 2021).

Quantitative indicators of critical discourse are growing rapidly: comics are becoming a space of interdisciplinary and an object of scientific interest in various directions of humanitarian studies. Figure 2 shows a selection from the Scopus database of articles for the period 1936–2022 that use the keywords “comics studies” or “comics” in their titles, keywords, or abstracts.

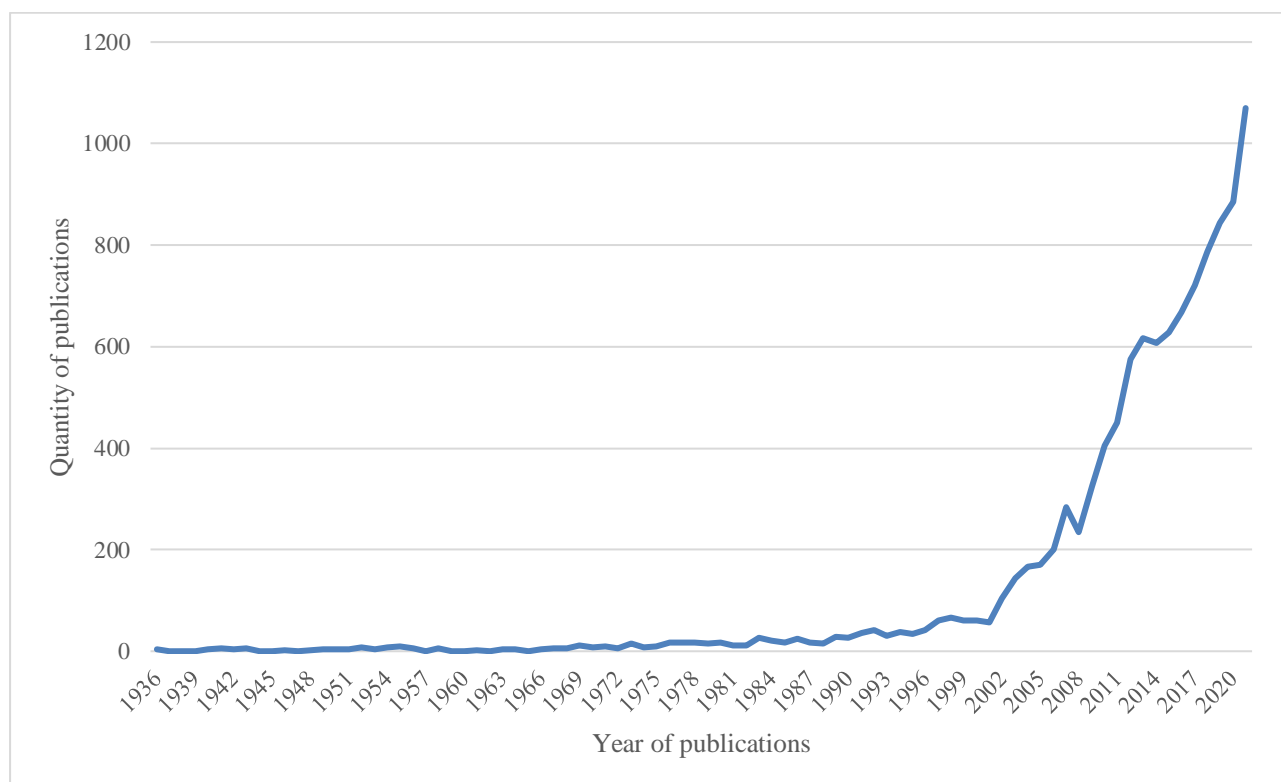


Figure 2. Dynamics of publications on the topic “Comics” (compiled by authors based on data from the SCOPUS database (2022)).

¹ Of the 10 Top Lifetime Grosses Movies in the World, five are based on comic books. According to box office mojo, their total revenue is more than \$10 billion. Source: based on https://www.boxofficemojo.com/chart/ww_top_lifetime_gross/?area=XWW&ref=bo_cso_ac

Further development was evidenced by the academic recognition of a new field of research:

- creating associations of scholars to study comics: American “The Comics Studies Society” (2014) with its own journal (Inks: The Journal of the Comics Studies Society) and a wide field of scientific interests, the German “Gesellschaft für Comicforschung” (ComFor, 2014), the “International Bande Dessinée Society” (2012), the “British Consortium of Comics Scholars” (2012), “Scottish Center for Comics Studies” at the University of Dundee (2011), “Canadian Society for the Study of Comics” (2010);

- printing of terminological dictionaries of the discipline (“Keywords for comics studies”, 2021; “Key Terms in Comics Studies”, 2021);

- master's and PhD programs at universities in the USA, Great Britain, European countries;

- international associations, platforms, and hubs (see e.g. Comics Research Hub (CoRH), University of the Arts London, 2019);

- dozens of monographs and defended dissertations (more than 20 in 2015–2016 alone), entry into the Scopus metric system of three editions “Journal of Graphic Novels and Comics”, “Comics Grid”, “Studies in Comics”.

Gene Kannenberg, chairman of the International Comic Arts Festival (1999–2000), made the first attempt to structure the scientific comics discourse on the portal www.comicsresearch.org. Later, the international status of powerful open databases of comics (for example, 400,000 indexed issues in The Grand Comics Database (GCD), the active involvement of volunteers from all over the world made access to online bibliographies global, and the dynamics of the development of Comics Studies were evident (for example, Bonn Online Bibliography of Comics Research international bibliographic database for scholarly literature about comics).

Gradually, the main directions of research into comics, graphic novels, strips and their cross-platform implementations in animation, digital media, and film were determined: comic theory, history, philosophy, semiotics, and criticism can only be singled out very conditionally. This contributed to the formation of a disciplinary context, and, as usual, an active scientific discussion of the principles of functioning, philosophical foundations, markers of the boundaries of a new discipline, and ethical problems when using the latest methods (Fawaz, Whaley, & Streeby, 2021; McNicol, 2019).

In February 2015, in an interview with “The Guardian”, Christopher Murray, the founder of the first master's program in Comics Studies at the University of Dundee (Scotland, United Kingdom), recognized the initial level of development of the scientific direction (under-developed area) due to the lack of a canon and the urgent need for innovative and interdisciplinary approaches. At the same time, he drew attention to the possibility of new methodologies to “break down disciplinary divides, work in the space of intersection of literature, art, history, politics, media” (C. Murray Comics studies has been undervalued for too long: We're fighting to change this. *The Guardian*. 2015, February 18.). In addition to the already-known educational opportunities, the author recognized creativity in solving the very problem of setting

tasks and methods of solving them as promising.

Within the framework of the history of science, this discussion is all the more revealing, since it takes place practically online, and comics act as “an aesthetic medium that also doubles as a conceptual terrain upon which the most central concerns of humanistic inquiry have and continue to be spectacularly rendered” (Fawaz, Whaley, & Streeby, 2021).

The accelerated development of the newest field, the active involvement of young and ambitious scientists in its development allowed Roger Sabin, editor of the “Palgrave Studies in Comics and Graphic Novels” series, to see the rapid transition of Comics Studies from a marginal interest to a disciplinary level: *“This series concerns Comics Studie – with a capital “C” and a capital “S.” It feels good to write it that way. From emerging as a fringe interest within Literature and Media/Cultural Studies departments, to becoming a minorfield, to maturing into the fastest growing field in the Humanities, tobecoming a nascent discipline, the journey has been a hard but spectacularone. Those capital letters have been earned”*.

Questions of disciplinary autonomy and scientific legitimacy are constantly raised by the young branch. “The Oxford Handbook of Comic Book Studies” (Aldama, 2020) presents the basic scientific mechanisms of disciplinary formation in a debatable and critical dimension. Drawing attention to the impossibility of self-sufficiency and closure of any scientific direction, Ch. Hatfield (2017) even introduces the characteristic of anti-disciplinarity as something that makes it impossible to define boundaries: “our field defies or at least seriously questions the compartmentalization of knowledge that occurs within academia”. But in 2020 he publishes a guide to comics studies (Hatfield & Beaty, 2020), which is nominated for the next year's Eisner Awards for the best academic/research paper, thus ironically revealing the metaphor of anti/inter/indisciplinarity and giving credit to “the field of comics studies has exploded” (from the abstract).

The birth of a new discipline, its separation and self-identification, despite the huge discourse of academic texts, the increase of thematic scientific journals, the opening of doctoral and master's programs in universities, is still a subject of debate – from Hetfield's anti-disciplinary approach to the rigid rejection of academicism by a large cohort of art fans and connoisseurs. Moreover, the history of the direction's development does not look like a traditional historical scientific path, constantly being in the space of paradigm shifts (paradigm shift) depending on the prism of scientific research (Cour et al., 2021, pp. 67–68).

In this sense, the history of Comics Studies stands as an antithesis to the traditional process of accumulating scientific experience. Benjamin Woo, pointing to the “paradigmatic status” of the discipline rhetorically asks: Where on the ancient and gnarled Tree of Knowledge shall we graft this new branch? (Woo, 2019). One cannot but agree with the researcher that even in the genesis of the emergence of the new discipline depended on unusual initial influences: comics writers and fans rooted the practices of critical studies of comics through their own attempts at the first generalizations. Subsequently, Comics' rehabilitation as both “literary” graphic novels and transmedia entertainment franchises has translated into a new confidence in their

“plausibility” as objects of scholarly attention. But the problem is more than defining disciplinary fields and boundaries: *“When we say that comics studies is a field, we are pointing to an intellectual community of people who have something to say about comics. To be a discipline, comics studies requires a metadiscourse, a backchannel where we can talk about how we talk about comics. The point is not to suppress or explain away difference but to focus in on the differences that are consequential and the debates that are worth having. Heretofore, our conversations about disciplinarity have largely been focused on the institutional appurtenances thereof—the “paraphernalia” of journals, learned societies, conferences, and, yes, faculty jobs. These are certainly important conversations to have if the achievements of comics scholars over the decades are to be sustained and carried forward by future generations. But we can’t neglect other, perhaps more difficult conversations about what comics studies has been, is, and could be”* (Woo, 2019).

Interdisciplinarity itself, as a core characteristic of comics research, is defined by most researchers as a “commonplace” and affects the scientific discourse of a widely divergent field (Jacobs, 2020), with a plurality of non-integrated and not always complementary methods (Dunst, Laubrock, & Wildfeuer, 2018).

As a way of creating a metadiscourse of a scientific direction through sustained, reflective, and collective effort, to expand the boundaries of the canon, legalized, usually, by literary approaches in the analysis of a documentary comic (we are talking about “Maus”, “Persepolis”, and “Fun Home”), to include audience-oriented methods of media studies in reflective practice. Thus, Jacobs offers an interdisciplinary tripartite approach that considers comics “as texts, material objects, and the locus of commercial and cultural transactions” (Jacobs, 2020).

Neil Cohn, a well-known researcher of comics, proposes to study them with a focus on the theory of visual language (Visual Language Theory), relying on the methods of cognitive and linguistic sciences and cross-cultural studies. The scientist supports the analysis of the multimodality of comic structures by creating the Visual Language Lab and curating the ambitious TINTIN project, which plans to analyze 1,000 comics from 75 countries of the world (<https://www.visuallanguagelab.com/>) using MAST (The Multimodal Annotation Software Tool), 4,200 pages of comics from 36 countries have already been analyzed, establishing interim results of a global study of cross-cultural patterns in the visual language of comics (TINTIN Project: Progress on Panels, 2022).

In this space of heated debates and scientific polyphony, Ukrainian comics today are taking a unique path of simultaneous formation of polythematic comic content and the initial formation of interdisciplinary academic discourse. The first is expressed by the creation of an active community and the formation of modern comic culture, the emergence of the national comic tradition and the expansion of the publishing market. The second is currently undergoing the traditional stage of an interdisciplinary approach involving philological, pedagogical, publishing, and communication methods. In January 2022, defended the first dissertation in Ukraine, “Ukrainian comics: library and information dimension”, specializing in information, library and archival business. Its author, Belov D., chronicled the history of Ukrainian comics:

humorous and propaganda comics of the 1920s–1930s (“Chervonyi Perets”, “Komar”); underground and emigration comics (1930s–1950s); Soviet Ukrainian comics of the 1950s–1970s with an emphasis on children's comics (“Perchenya”, “Barvinok”, “Malyatko”); Ukrainian comics at the beginning of Ukraine's independence (1990s–2010s) and, finally, contemporary Ukrainian comics (Belov, 2021). Considering the issues of the work, the national strategies of comic criticism and the formation of a library and information service around comic culture are summarized for the first time.

Conclusions.

Therefore, at the first stages of cooperation between science and the art of sequential images, the visual rhetoric of comics organically fit into the audience habits and traditions of mass culture. The desire to interest and expand the audience made popular science, and biographical series vivid, scientific discoveries were presented in a traditional heroic style, and scientists became real saviors and role models. The direction of popularizing research through comic techniques today has taken various forms, and the purposeful use of CBR has become a common practice of both individual scientists and universities, scientific laboratories, libraries and institutions.

The newest scientific field of comics research has gone through various stages of its formation, first in a harsh confrontation between high and low culture, then in an ambivalent combination of entertainment and education, with the further development of philosophy, theories and histories of comics. These stages and scientific components did not always develop consistently, and even more so, they did not cancel previous acquisitions and, unfortunately, prejudices. The comic is unique in its exceptional appreciation for successful decisions, it actively replicates them at different times, and offers to relive familiar experiences, and implements tried and tested ideas in new forms.

It is quite logical that on the path of various vector directions of scientific understanding of comics, there will be attempts to unite them into a single disciplinary space, following the example of traditional crossovers and Multiverses of well-known comic's epics. At the same time, the first results of a comprehensive analysis of the “living reality of the world of comics” (Woo & Stoll, 2021) point to the extremely difficult task of modern dialogue between comic artists, readers, publishers, scientists, critics, and journalists in understanding the comic and the scientific space around it.

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Наука і комікси: від популяризації до дисципліни Comics Studies

Анотація. Сучасна наукова комунікація традиційно використовує візуальні наративи, такі як комікс, задля освіти, презентації наукових здобутків масовій аудиторії і як об'єкт дослідження. В статті пропонується трирівнева характеристика взаємодії коміксової культури та науки в діахронічному аспекті. Акцентується увага не тільки на хронологічних етапах цих перетинів, увиразнення специфіки взаємодії пропонується на тлі наукових і громадських дискусій, що супроводжують діалог комікс–наука і до сьогодні. В межах першого етапу (поява і поширення науково-популярних та освітянських коміксів) виокремлені важливі для подальшої генези характеристики комікс-контенту: документальний сторітелінг, освітянські практики навчання через малюнок, активна співпраця з відомими компаніями та закладами, інформативність та емпатична залученість молодого читача до героїко-

романтичного наративу наукових відкриттів та освоєння природи. З активізацією міждисциплінарних підходів (другий етап) комікс все частіше залучається до презентації наукових результатів в межах найрізноманітніших галузей. Comics-based research становиться міждисциплінарною методикою та поширеною практичною сферою з відповідним формуванням наукового інструментарію (прикладний комікс, дата комікс), формами міждисциплінарної взаємодії (графічна медицина, етнографіка, наративна географія, урбаністичний комікс, коміксова журналістика тощо) і науковими виданнями (“The Comics Grid: Journal of Comics Scholarship”, “Sequentials”). На прикладі українських коміксових проєктів (історичний, феміністичний комікс) представлено національний формат comics-based research. У генезі розвитку comic studies пройшли шлях від поля досліджень до дисциплінарних дефініцій. У створенні метадискурсу наукового напрямку (третій етап) авторами зосереджено увагу на наукових дискусіях, формуванні академічних напрямів і підходів та на маркерах дисциплінарної самоідентифікації. Закцентовано на унікальному феномені одночасної суголосності різних етапів діалогу коміксу та науки, на подовженій реплікації вдалих винаходів у сучасний досвід, активна апробація знаних наративів на нових рівнях наукової презентації.

Ключові слова: наукова комунікація; прикладний комікс; дослідження на основі коміксів; дослідження коміксів

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Vernadsky's concept of the noosphere and its reflection in ethical and moral values of society

***Abstract.** The paper assesses the topicality of Vernadsky's concept of the noosphere, coined over almost twenty years starting in the early 20th century. Emphasizing the uniqueness of Vernadsky's concept of the noosphere as the transformation of the biosphere by a man using reason, we concentrate on the assessment of the utopian or realistic nature of his vision of the future of humanity. Based on the philosophical case-studies analysis, it identifies the ideological roots of the noosphere concept, the development of views on the concept in time, the role of reason and scientific thinking, the opinions of its supporters and critics, and Moiseev's related concept of co-evolution. We point out the correlation between Vernadsky's concept of the noosphere and Moiseev's bifurcation and his two imperatives as necessary conditions for the co-evolution of nature and man. We document that Vernadsky did not only think about the positive role of reason in the creation and development of the noosphere, but he was also aware of the possibility of its misuse. We compare Vernadsky's idea of the collective reason creation with Kurzweil's concept*



of technological singularity, Crutzen's concept of the Anthropocene, Haff's concept of the technosphere and Cer's scenario of the possible future development towards the creation of tech subjects and the replacement of the biosphere with the technosphere. We also assess the possibility of approximating essential concept-forming elements, i.e. philosophical categories, collective reason, the collective intelligence of humanity, and scientific knowledge facilitated by information and communication technology. Ultimately, conclusions concerning the topicality of Vernadsky's concept of noosphere are formulated. We argue that Vernadsky's concept of the noosphere is timeless and should be taken not as a utopia but, on the contrary, as a scenario of possible development along the line of geosphere – biosphere – noosphere, prospectively with its transfer to the cosmic dimension.

Keywords: *biosphere; noosphere; co-evolution; scientific thinking; ethics*

Introduction.

The concept of the noosphere (see Appendix A, 1) conveys an extraordinarily complex and contradictory phenomenon for science, philosophy and culture. Its authors believed that human reason, in the form of a planetary geological force, will lead to more perfect forms of existence (Fuchs-Kittowski & Krüger, 1997; Rezhabek, 2008; Oldfield & Shaw, 2013; Hamilton & Grinevald, 2015). Regarding the original idea of the noosphere, it is especially the concepts of Vernadsky and Teilhard de Chardin that have been subject to discourse over the long term. While Teilhard's noosphere is firmly rooted in the existence of God's intention, Vernadsky's concept of the noosphere is created along a trajectory of geosphere-biosphere-noosphere as new quality, i.e. “biosphere processed by scientific thinking” (Vernadsky, 2004, p. 277). In the light of current global challenges concerning the planet's ecosystem, Vernadsky's concept is being increasingly discussed, not only in Russia (Trubetskova, 2010; Ursul, A. D. & Ursul, T. A., 2020; Palagin, Kurgaev & Shevchenko, 2017; Fesenkova, 2019;), but also worldwide (Hamilton & Grinevald, 2015; Grinevald & Rispoli, 2018; Ronfeldt & Arquilla, 2018; Liseev, 2020). The philosophical foundations of Vernadsky's noosphere consist of collective/global reason, collective intelligence, and global scientific thinking (Vernadsky, 1926, 1945, 2004).

This paper aims to analyse the essential attributes of Vernadsky's concept of noosphere, its development over time, as well as the possibilities of approximation of its essential concept-forming elements – philosophical categories of collective reason / collective intelligence of humanity and scientific knowledge facilitated by ICT. It is organised into introduction, philosophical case-studies, results and discussion, and conclusions. Based on a case-studies analysis of polemical, critical and concept-developing papers on noosphere, we formulate conclusions regarding both the degree of its reality (or utopianism), its topicality and openness to new knowledge and its compliance with Christian values.

Ideological roots of the concept of noosphere.

Although the neologism noosphere was coined in Paris in 1927, some ideas on integrity and harmony of the universe, on the interdependence of micro and

macroworlds, the essence of the world, the structure of matter, the cosmic nature of life and reason, the need for man's spiritual and moral improvement had been discussed long before in philosophy, theology, art and mythology. Some examples are Akasha in Indian cosmology, Logos in the teachings of Heraclitus, Plato's Eidos, Spinoza's Nature naturing, Popper's Third World (see Appendix A, 2), etc.

Vernadsky's concept of noosphere represents a positive view of the role of reason, scientific thinking, and social activity of people in the transformation of nature. It was mainly shaped under the influence of the Russian cosmism (see Appendix A, 3), in which it is possible to trace naturally scientific, fantastic, utopian, realistic, religious, and poetic buds of the idea of the noosphere (Krichevsky, 2008; Bondareva, Semaeva & Moisejkina, 2018).

Although both Vernadsky and Teilhard de Chardin have contributed differently to the content of the noosphere concept, there are also common points that connect them (Levit, 2000, 2000a). While Teilhard de Chardin presupposes the formation of the noosphere independently of human actions, Vernadsky (2004, p. 240) understands the origins of the noosphere as an objective continuation of the evolution of the biosphere influenced by scientific thinking and the reason the humankind. He views the inception of intelligent life as part of the biogeochemical process taking place in the evolution of the biosphere on the Earth: “Scientific thinking is a part of the structure of the organisation – the biosphere... its creation in the evolutionary process of life is an event of utmost importance in the history of biosphere and the history of planets” (Vernadsky, 2004, p. 381). However, at the same time, he also highlights the importance of morality, ethics and collaboration of humans in preserving the future of humankind (Vernadsky, 1965; Levit, 2000, pp. 165–167; Hamilton & Grinevald, 2015, p. 8).

Vernadsky's concepts of biosphere and noosphere.

Vernadsky defines the biosphere (see Appendix A, 4) as “a geological envelope of the Earth of finite size, significantly different from all other geological envelopes of our planet”, which “separates the planet Earth from the cosmic medium”. The biosphere (see Appendix A, 5) is metaphorical “rational mantle of the Earth”, and living matter gives the biosphere “specific character, unique in the universe” (Vernadsky, 1944, p. 488). His biosphere concept has got two dimensions – naturally scientific (biogeochemical process as a driver of evolution) and philosophical (planetary evolution, the concept of unity of living and inert matter). The biogeochemical process is characterised by “a special spatial natural phenomenon, where space is not geometric, and time is, does not manifest itself in the form of the fourth coordinate, but in the form of a change of generations” (Vernadsky, 1965, p. 201). At the philosophical level Vernadsky's biosphere is a specific biological form of mass motion, in which billions of tons of matter are transformed. At a particular stage in the biosphere's evolution, humans inevitably emerge, equipped with reason. Living and inert matter together form the system of the biosphere. Humanity and the natural environment together form the system of the noosphere. Humanity – the *Homo sapiens* – Faber species is the driving force to transform biosphere to noosphere: “Humanity as a whole is becoming a powerful geological force” (Vernadsky, 1965,

p. 328). Vernadsky presents the noosphere as a state that has already existed: “The biosphere has moved or gone to a new evolutionary state, the noosphere” (Vernadsky, 1988, p. 30) and as a state that is to be: (entry into the era of noosphere). “The biosphere has passed or rather is passing into a new evolutionary state called the noosphere. It is processed by the scientific thinking of social humanity” (Vernadsky, 1988, p. 30)... “The biosphere will inevitably pass one way or another, sooner or later into the noosphere...” (Vernadsky, 1988, p. 46).

The transformation of the biosphere to the noosphere is inevitable, resulting from an objectively ongoing evolutionary process. It is “... the last of many stages in the evolution of the biosphere in geological history” (Vernadsky, 1945, p. 10). The transformation of the biosphere into the noosphere “is an inevitable geological process” (Vernadsky, 2004, p. 335).

Moreover, there is no coincidence in evolution: “... in the paleontological development of organised beings; there is a certain direction and the emergence of reason, consciousness, governing will in the biosphere – the basic human manifestations – it cannot be accidental” (Vernadsky, 1993, p. 297). Vernadsky's first biogeochemical principle of the ability of living matter is, under optimal conditions, multiplying indefinitely, as he defines it as “Biogenic migration of atoms of chemical elements in the biosphere always strives for its maximum expression”. Biogenic migration of atoms is associated with the activity of living organisms (Vernadsky, 1965, p. 283). According to the second biogeochemical principle on the direction of the evolution of organisms, “evolution of species during the geological time leading to the creation of life forms stable in the biosphere goes in a direction that increases the biogenic migration of biosphere's atoms” (Vernadsky, 1965, p. 283). According to the first principle, living matter strives for the maximum attack on inert matter. It can be conveyed as a code of life/living matter aggression towards the biosphere. The second biogeochemical principle determines the direction of evolution – evolution proceeds in a direction towards the origin of a species, which has the most remarkable ability of biogenic migration, i.e. towards the most aggressive species. Humans are such species, equipped with human brains and work (Fesenkova, 2018, pp. 10–11). It follows that, there is an organisation created by living matter in the system of nature, and, at the same time, there is an effort to destroy any organisation in the same living substance that forms the organisation. The contradiction eliminates the origin of a man as the bearer of reason.

The idea of the noosphere is, assuming the unification of humanity by the power of scientific thought, a construct directed against the laws of life aggression, in which the role of reason is fully manifested: “... at the beginning of the 20th century, a force appeared in a clear, true form, enabling the unification of humanity – scientific thinking... This is a force of geological nature made ready by billions of years of life's history in the biosphere...” (Vernadsky, 1988, p. 69).

Vernadsky viewed human reason as an element of the organisation of nature. It can transform nature and unite humanity and create an ideal society promoting the idea of harmony between man and nature (Fesenkova, 2013, pp. 138–146) and eliminating the danger of the ecological crisis. Vernadsky believes that reason is inscribed in

evolution, evolves according to its laws, and fulfills its goals. It follows that the noosphere's formation as a natural phase in the evolution of the biosphere is irreversible. According to Vernadsky, reason is the highest degree of rational and purposeful force that organises nature. The reason must improve its habitat according to the laws of evolution and transform the biosphere into the noosphere (Vernadsky, 1965). His interpretation of man's role in the creation of the noosphere is not built on the scientific understanding of the objects under investigation but on a clearly defined philosophical position – ontological idea of the structure of the universe. Man is a product of nature, the result of its long development, during which the most fantastic phenomenon came to exist – human reason. Vernadsky's concept of the noosphere, based on declaring the decisive role of human activity and reason in the transformation of the biosphere, represents a model of possible development, based on humanity's ability or will to act rationally, on a planetary scale. According to Vernadsky, *Homo sapiens* need to be rational not only according to one's evaluation, but also following the ideals of good, justice, beauty, and reason: “For the first time, a man truly understood that he was an inhabitant of the planet and may – must think and act in a new aspect, not only in the aspect of the individual, family or clan, states or their alliances but also in the planetary aspect” (Vernadsky, 2004, p. 262).

The task of the noospheric man is to use reason to preserve all the qualities of the biosphere necessary for the survival and development of humankind. A metaphor about the noosphere as a kingdom of reason (Vernadsky, 1988, p. 127) seems to give an exclusively positive connotation to reason. However, Vernadsky points out that man's role is to use reason to preserve all the qualities of the biosphere necessary for the survival and development of humankind. The transcript of his lectures about the results of his thirty-year reflections on the role of human consciousness (reason) as an ontological category and active factor in the development of the biosphere, which influences the course of natural processes (Nazarov, 2008, pp. 74–75) is crucial. Here, we can find a statement about the possible divergence of the direction and intensity of technological progress of the humankind and the development of natural processes in the biosphere (see Appendix A, 5). Evil is a current phenomenon in the noosphere as good is: “... the biosphere knows neither good nor evil ...”. The question of the moral side of science – regardless of the religious, state or philosophical expression of morality – is becoming an effective force and will have to be reckoned more (Vernadsky, 2004, p. 342). We can see it in misuse of reason and the results of scientific thinking, corresponding to Heidegger's concept of *Gestell*, according to which “Everything is ordered to stand by, to be immediately at hand, indeed to stand there just so that it may be on call for a further ordering... We call it the standing reserve (*Bestand*)... Whatever stands by in the sense of standing reserve no longer stands over against us as an object. We now name that challenging claim which gathers man thither to order the self-revealing as standing-reserve: *Ge-stell* (*Enframing*)” (Heidegger, 1977, pp. 17–19). Therefore, today, technology is becoming a force that is moving nature into the position of standing reserve – *Bestand*.

Results and discussion.

It should be emphasized that Vernadsky describes his concept's implementation possibilities very carefully: "... the creation of the noosphere from the biosphere is a natural phenomenon that is inherently deeper and stronger than human history. It requires the expression of humanity as a unified whole... It is a new stage in the planet's history that does not allow to use its historical past for comparison without any changes" (Vernadsky, 2004, p. 262).

However, this raises the question of to what extent the biosphere should be transformed by human reason to make a qualitative leap from the biosphere into the noosphere (Liseev, 2020, p. 27). So far, it seems that the noosphere creation process, according to Vernadsky's concept, is replaced by the process of creation of the technosphere. The technosphere is an environment created by humanity that (see Appendix A, 8) "... objectively exists and develops as an artificial autonomous global system of technical reality outside the Earth's biosphere" (Krichevsky, 2017, p. 156).

Man is probably not yet morally prepared to take responsibility for the state of the natural environment and the co-evolution of society and nature. For example, Moiseev (1990, pp. 262–263) attached particular importance to the man's benevolent attitude towards himself and the ambient nature. In his view, the principle of benevolence "should form the basis of the moral imperative and the whole system of education" of man.

Therefore, the noosphere concept must correlate with the ongoing processes on the planet. The degree of harmony between the needs of socio-economic development and the possibilities of nature indicates the degree of approximation to implementing the noosphere concept (Moiseev, 1995, pp. 211–212). Ursul (2014, p. 1507) notes that "the noosphere is a materialistic and idealistic formation, in which reason/mind (or wisdom) in various forms is the dominant factor, but above all in the form of a global collective noospheric intellect". Moreover, Ursul A. D. & Ursul T. A. (2020, pp. 69–77) highlight that "preservation of the biosphere and survival of mankind is the cardinal purpose of the transition to sustainable development... In the near space future, mankind will have to massively ship the production of energy and materials outside the planet".

According to Duvigneaud (as cited in Plotnikova, 2004, p. 79), we "... have turned our attention to the noosphere... the after us, the flood policy must be stopped, and our efforts must be united to take effective measures to make reasonable use of the biosphere's resources. And then what reasonable people call utopia today will become a reality tomorrow".

From its inception, Vernadsky's concept of noosphere has been subject to criticism by several authors not only from the former Soviet Union, such as Kuttyrev, (1990, 1996), Pozdnyakov (2003), Zavarzin (2010), Borejko (2013) but also Viner (1995), Levit (2000), Borejko, (2001). Vernadsky has been reproached for its utopianism, exclusively positive direction of reason and failure to respect the facts.

The utopianism of the concept as such: the concept of the noosphere is "a utopian and scientifically unsustainable idea" (Viner, 1995, p. 90), "The noosphere as harmony – is a scientific analogy of such socio-political utopias as the likes of communism and

other, earlier dreams of paradise... We need realistic hopes, functional utopias... These hopes and utopias must be distinguished from the illusions arising from the hope of the boundless power of reason as logos...” (Kutyrev, 1996, p. 154). In Kutyrev's opinion, there are axiological and ontological approaches intertwined in the noospheric teachings without further definition and the value characteristics of noogenesis are presented clearly in a positive manner, which contradicts the dialectic of life (Kutyrev, 1990, p. 4). According to Stilmark, “the idea of the noosphere, the idea of a harmonious fusion of nature and society, is in principle deeply idealistic and now utopian” (Stilmark, 2001, p. 11), and according to Levit the concept of the transition from the biosphere to the noosphere cannot be considered scientific (Levit, 2000a).

The utopianism of the idea of an exclusively positive direction of reason: the basis of the doctrine of the noosphere is the idea of controlling the biosphere's transformation by reason. In reality, however, the man is inside nature, and the man cannot control nature – the man does not know the goals of evolution and pursues a different, selfish goal: to adapt nature to himself. The idea of the noosphere represents only “insufficiently substantiated utopian provisions on human omnipotence” (Pozdnyakov, 2003, p. 11).

Failure to respect the facts: “the human reason is objectively weak... it is not gifted to predict the possible negative consequences of major scientific discoveries and their use” (Borejko, 2013, p. 142); “the flow of information processed by natural biota in biotic regulation is twenty orders of magnitude higher than the flow of information processed by modern civilization” (Gorshkov, 1996, p. 137).

A refinement of Vernadsky's concept of the noosphere is found in the concept of co-evolution by Moiseev (1999, 2000, 2001) as coordinated, tolerant and equal simultaneous development of various components of the ecosystem, in particular, human civilisation and nature. Moiseev sees the matter in the scope of co-existence of a self-organising universe and humanity: the universe is an infinitely complex interconnected organism, and humanity, endowed with reason, is one of its subsystems. The reason is a cosmic phenomenon, but as such, “... it is not able to make planetary process controllable” (Moiseev, 1999, p. 271). Moiseev developed the concept of the noospheric future of humanity and its inner concept of a new morality, i.e. the morality of the noosphere. He interprets morality and ethics not as a rigid set of rules but as an appeal to man's conscience and knowledge. The nature of a person's decisions should be determined by one's creativity combined with mercy and love of neighbour. In this context, he introduced the notion of the noosphere era as a stage in history in which collective intelligence, collective will, noospheric morality and ethics can ensure the co-evolution of nature and society. According to Moiseev, the concept-forming elements include the concept of global bifurcation (see Appendix A, 6), the concept of ICT as a catalyst in the process of the emergence of collective intelligence, and the concept of society's development at a varying rate and development of the logic of nature (Moiseev, 2001, p. 19). There have been two bifurcations in the history of planetary evolution: the origin of life and the origin of reason. The formation of the collective reason of humanity will be the third bifurcation in a row (Moiseev, 2001, p. 116).

According to Moiseev (1988, 1990, 1990a, 1993, 1995, 2000), the limits for human intervention in the biosphere are set by the so-called ecological imperative, which sets “that limit of permissible human activity which one has no right to cross under any circumstances to avoid destroying the biosphere's self-organisation mechanisms... does not depend on the will of an individual, but is given by the relationship among the characteristics of the natural environment and the physiological and social characteristics of the *Homo sapiens* species” (Moiseev, 2000, p. 79).

The role of human reason is also stressed in the Anthropocene concept: “Anthropocene, the current epoch in which humans and our societies have become a global geophysical force”. (Steffen, Crutzen & McNeill, 2007, p. 614). Similarly, Haff's concept of the technosphere raises important questions regarding human agency and the controllability of large-scale technologies, as well as the role of technology in the interrelation between human societies and other parts of the Earth system. the technosphere follows some physical law or quasi-autonomous dynamics, such as the principle of maximum entropy production (Haff, 2014).

Popkova (2014, pp. 311–312) added that rather than the transforming biosphere, it is the universe as a whole that is the critical system of evolution. Suppose the regulatory and compensatory-relaxation functions performed over vast biological diversity. In that case, its information content ensures the stability of the biosphere, then noospheric intelligence will ensure the process of human adaptation to the biosphere (Ursul, A. D. & Ursul, T. A, 2015, pp. 35–37).

The current noospheric discourse places the harmony of the evolution of man, society, and nature and their safe and long-term joint development in the forefront (Moiseev, 2000; Griffen, et al., 2022).

Disputes around Vernadsky are inevitable, but they are useful only in that if they lead to a more thorough comprehension of the views of the scientist (Vernadsky, 2000, p. 768). The rejection and criticism of the concept of the noosphere can be explained by several reasons, both scientific and ethical. One of the main objections to the supporters of the noosphere seems to be the indisputable fact of the destruction of the biosphere by reasonable humans. The existence of reason does not automatically ensure its proper use in favour of co-evolution: a required paradigm shift is a complicated process, and humanity will agree to it in critical situations only. Morality, however, is an expression of the human path to the good. This includes the ability to sacrifice one's interests to benefit the wider community. It is not easy to motivate individuals to do so in a situation where fundamental problems require a change in the approach of the human community as a whole. Suppose the development of society is determined primarily by economic factors. In that case, the gap between the technological capabilities of society and the level of its intellectual responsibility for the biosphere will widen even further. The basis of action according to the noospheric morality is unconditionally good. The experience of touching universal values that guide a person's behaviour is at the heart of such behaviour, no matter the consequences.

On the outside, the concept of a global reason of humanity appears to be the most utopian element of Vernadsky's concept of noosphere. Based mainly on the ideas of

John Lawrence LeCont (psychozoic era), James Dwight Dan (cephalisation), A. P. Pavlov (anthropogenic era), Vernadsky (2004a, p. 476) wrote: "... the evolution of living matter is going in a certain direction". It places the origination of the noosphere in correlation with the origination of reason: "the reason is a complex social structure... Its change is the main reason that ultimately led to the transformation of the biosphere into the noosphere..." (Vernadsky, 1988, p. 133). The global reason of humanity acts as a harmoniser of social and biospheric relations. Moiseev and Frolov see the essence of Vernadsky's concept of the noosphere in the provisions concerning harmonious development of society and governance by the organisation of the biosphere (Moiseev & Frolov, 1984, p. 39). Such development represents a higher quality, created by the synergic effect of biological evolution and scientific knowledge. "The main geological force that creates the noosphere is the growth of scientific knowledge" (Vernadsky, 1988, p. 49). "From the surrounding life, scientific thinking takes over the material that it transforms into the form of scientific truth. It is a spontaneous reflection of a man's life in the environment that surrounds him – in the noosphere" (Vernadsky, 1988, p. 53). Without the emergence of the human brain, there would be no scientific thinking in the biosphere, without which there would be no geological effect either – the restructuring of the biosphere by humankind (Vernadsky, 1988, p. 59). At a certain stage of this evolution, a man equipped with reason inevitably arises, and thus cultural biogeochemical energy, which together creates the conditions for the formation of the noosphere: "This new form of biogeochemical energy ... is the form of energy that currently creates the noosphere" (Vernadsky 1988, p. 132). The collective reason, defined as one that integrates the minds of individual people, provided that they retain their individual consciousness, is here a prerequisite for further noospheric development and its outcome. Moiseev explains the possible origin of collective reason using an analogy to the source of the human neural network. Suppose an increase in the number of neurons in the brain of a living creature once led to the emergence of consciousness having properties that are not only a simple sum of the properties of the individual neurons. In that case, a similar process might lead to the emergence of collective reason. The role of neurons will be played by individual human minds and artificial information systems: "Collective reason is a systemic property of a set of individuals who have (their own) reason and ability to exchange information" (Moiseev, 1993, p. 48). The emergence of selective intelligence of humanity is another conditional factor of humanity's transition to the co-evolutionary path of development of society and nature (Moiseev, 2001, p. 116). "If my hypothesis is correct, one day there will inevitably be a qualitative change in the position of collective reason (see Appendix A, 7) in the planetary organisation of mankind" (Moiseev, 2000, p. 89). In addition to the possibility of the emergence of collective reason and/or intelligence through biological evolution, the contours of its emergence in an alternative (technological) way are beginning to appear today, thanks to the development of knowledge and ICT (Tegmark, 2020).

As far as the role of technology and especially ICT in implementing the noosphere concept is concerned, Kurzweil (2005) argues that technology has functioned from the very beginning as a geological force having an intensity that increases exponentially

over time. His concept of the emergence of a technological singularity assumes that the capabilities of the human brain will be surpassed shortly: “The Singularity will allow us to transcend these limitations of our biological bodies and brains” (Kurzweil, 2005, p. 9). By the mid-2040s, computer-based intelligence will significantly exceed the total human brainpower (Kurzweil, 2005, pp. 135–136). According to Floridi (2019, p. 113), the penetration of ICT into people's lives caused the onset of the so called Fourth Revolution, the effects of which are reminiscent of the concept of global reason: rather than isolated Newtonian subjects people are now information organisms (inforgs), interconnected (also with other types of information organisms) and rooted in the information environment (infosphere). As for the future development, Cera (2017, p. 268) holds the opinion that technology will displace nature from the position of the natural environment of man: “Technology emerges as the possible oikos for today's humanity”. Moreover, technology will create the pressure for the emergence of an evolutionarily new post-human subject: “a man completely adapted to the technological neoenvironment... who is totally fused with his vital space...” (Cera 2017, p. 269).

The Internet and ICT, in general, are often presented as technological approximations of the concept of noosphere. In general, Wikipedia and online collaboration platforms and social media are presented as the first swallows of the approximation of collective reason, i.e. noospheric intellect. At the abstract model level, an analogy between the self-evolutionary model of the neural network and the collective reason is presented. According to this analogy, collective reason (or consciousness) can develop much faster than the reason (or consciousness) of the individual (Sulejmenov et al., 2013, p. 89).

Conclusions.

As one of Vernadsky's quotations states: “The kingdom of my thoughts is yet to come” when formulating conclusions about the degree of realness or utopianism of the noosphere, one must take into account that the time of its implementation is measured on a scale of tens of human generations. Therefore, nowadays, it is not possible to speak unequivocally about its confirmation or non-confirmation. In this context, there are two critical statements by Vernadsky analysed below.

“Humanity as a whole is becoming a powerful geological force. And before it, before its reason and work stand the challenge of restructuring the biosphere in the interests of broad-minded humanity as a whole” (Vernadsky, 1988, p. 509). “... geologically, we are now experiencing the exclusion of the kingdom of reason from the biosphere, which will radically change both its appearance and its structure into the form of noosphere” (Vernadsky, 1988, p. 127).

Indeed, we can also find some value judgements in his notions of the noosphere, hypotheticality, an absence of a unifying, deeply substantiated concept, and a coherent theory of the biosphere's transformation into noosphere. Many of Vernadsky's statements on the noosphere are accompanied by remarks such as “I will come back to this in the future”.

Rather than a holistic and profoundly developed concept of noosphere, it is an outline of such model of biosphere's evolution that would take the action of humanity as a global geological factor fully into account. However, it is not clear how it would be possible to regulate the impact of human activity on the biosphere effectively. That is why the existence of conflicting evaluations of his concept of the noosphere is not accidental at all (Liseev, 2020, p. 26).

Vernadsky hoped that humanity would be spiritually transformed and guided by scientific ideas and high moral principles. His concept of the noosphere coincides with the need for a new morality, new rationality, and a new noospheric humanism (see Appendix A, 9). Man will move forward the process of his spiritual evolution, which will result in the formation of noospheric consciousness as a process of spiritual asceticism.

The structure of a noospheric society will be determined by the principal contradiction of the noospheric evolution – the controversy between the spiritual and material components of civilisation's life. This contradiction can be resolved by forming a global noospheric consciousness and the system of a noospheric society, and the collective mind (reason) becomes its basic element.

Epistemological and axiological pessimism regarding global noospheric development can be largely overcome by consulting the works of Vernadsky: “We can see that this is the beginning of a spontaneous movement, a natural phenomenon that cannot be stopped by coincidences in the human history” (Vernadsky, 2004, p. 261). Vernadsky viewed the transition to the noosphere as a necessity. He considered the transformation of the biosphere into a new evolutionary state to be a necessary step. He thought that changing the man of the biosphere to a new man of a new noospheric reality governed by new ethics, ideals, and morality was principal.

The paper was created in the midst of a coronavirus pandemic (COVID-19), which clearly showed the unpreparedness of humanity, oriented towards other goals, to respond to such global challenges. The reminder of Vernadsky's ideas is an opportunity to emphasize the basic attributes of human existence: health, happiness, co-operation and development of moral and spiritual values.

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Conflicts of interest.

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Appendix A: Notes

1.	Noosphere	The term noosphere is formed by combining the Greek words noos (reason / mind) and sphaira (sphere). The noosphere, then, is literally the sphere of the mind / reason.
2.	Popper's Third World	According to Popper (2000, p. 72), if we use the word world as a metaphor, we can identify three worlds, of which World “... contains all books, all libraries, all theories, including, of course, erroneous theories and even contradictory theories...” Popper (2002, p. 85) does not consider himself the discoverer of the Third World: “Everyone knows that Plato was the discoverer of the Third World” He means the world of eidos, or the world of ideas and forms.
3.	Russian cosmism	The main intention of Russian cosmism that determines the essence of its civilisational concepts, is the idea of the unity of man and the Cosmos – man is called to bring reason and well-being to nature.
4.	Teilhard de Chardin's concept of noosphere	Teilhard de Chardin draws an imaginary evolution of noosphere: Noosphere of the Earth will be replaced by a super-reason and will result in the so-called Omega point, in which “a large amount of consciousness is accumulated and gathered in its perfection and integrity that is gradually released on the Earth...” (Teilhard de Chardin, 1987, p. 206; Levit, 2000, pp. 166–167). For a detailed

		description of Teilhard de Chardin's concept, see Teilhard de Chardin (1987).
5.	Vernadsky's concepts of biosphere	The term biosphere was coined in the 19 th century by Eduard Suess as “a set of organisms confined to space and time and inhabiting the surface of the Earth” (Oldfield and Shaw, 2013, pp. 291–292)
6.	Bifurcation	The term bifurcation comes from Latin bifurcus, i.e. divided into two branches or parts, and is used in a broader sense to denote all kinds of qualitative transformations or metamorphoses of different objects with changing parameters they depend on.
7.	The concept of global collective reason	For more on the concept of global collective reason, see Moiseev (1999, 2000).
8.	The concept of technosphere	The technosphere concept has been introduced by Haff (2014)
9.	Noospheric humanism	Through the prism of noospheric humanism, one can see the essence and meaning of the spiritual-cosmic evolution of man and humanity.

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Концепція ноосфери Вернадського та її відображення в етичних і моральних цінностях суспільства

***Анотація.** У статті оцінюється актуальність концепції ноосфери Вернадського, яка формувалася протягом майже двадцяти років, починаючи з початку ХХ століття. Наголошуючи на унікальності концепції Вернадського про ноосферу, як перетворення біосфери людиною за допомогою розуму, ми зосереджуємося на оцінці утопічного чи реалістичного характеру його бачення майбутнього людства. На основі аналізу філософських кейс-стаді визначено ідеологічні корені концепції ноосфери, розвиток поглядів на цю концепцію в часі, роль розуму та наукового мислення, думки її прихильників і критиків, а також пов'язану з нею концепцію Моїсеєва. Вказуємо на співвідношення концепції ноосфери Вернадського з роздвоєнням Моїсеєва і двома його імперативами як*

необхідними умовами еволюції природи і людини. Ми підтверджуємо, що Вернадський не лише думав про позитивну роль розуму у створенні та розвитку ноосфери, але й усвідомлював можливість його зловживання. Ми порівнюємо ідею створення колективного розуму Вернадського з концепцією технологічної сингулярності Курцвейла, концепцією антропоцену Крутцена, концепцією техносфери Хаффа та сценарієм Сера про можливий майбутній розвиток у напрямку створення технічних суб'єктів і заміни біосфери техносферою. Ми також оцінюємо можливість наближення основних концептуальних елементів, тобто філософських категорій, колективного розуму, колективного інтелекту людства та наукового знання, сприянню інформаційно-комунікаційним технологіям. Зрештою, сформульовано висновки щодо актуальності концепції ноосфери Вернадського. Ми стверджуємо, що концепція ноосфери Вернадського є позачасовою і її слід сприймати не як утопію, а, навпаки, як сценарій можливого розвитку по лінії геосфера – біосфера – ноосфера, перспективно з перенесенням її в космічний вимір.

Ключові слова: біосфера; ноосфера; еволюція; наукове мислення; етика

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On Hooke's Rule of Nature

Abstract. *Lectures de Potentia Restitutiva or Of Spring: Explaining the Power of Springing Bodies (1678) is an important book for the history of science. This book is better known for Hooke's presentation of the law that bears his name. This law, or "Rule of Nature" as the author states, is commonly taught within the context of the analysis of elastic bodies and their deformations. However, the framework in which this law was introduced goes beyond the context in which it is currently taught. Alongside the presentation of Hooke's experiments with springs, the author established his vibratory theory of matter, in which the concepts of congruence and incongruence, initially presented in his Micrographia (1665), would be defined in greater detail. These concepts aimed to theoretically justify the movements of attraction and repulsion in nature. This paper seeks to study the Lectures de Potentia Restitutiva once again to better understand Hooke's thoughts about the rule which bears his name and his conception of gravity, which the author considered a force. Here Hooke's definitions of body and motion will be presented, as well as his actual objective when he formulated the so-called Hooke's Law. As we will see, Hooke intended to create a "philosophical scale" to measure the gravitational attraction between bodies. By considering his previous publications, such as An attempt to prove the motion of the Earth from Observations or Micrographia: or some Physiological Descriptions of Minute Bodies, or even unpublished works such as On the inflection of a direct motion into a curve by supervening Attractive principle, it becomes clear that Hooke was already opening a path toward an understanding of gravity before Newton's Principia (1687) were published. By taking into account the controversy between Isaac Newton and Robert Hooke, we also intend to strengthen the idea that Hooke was an indispensable contributor to the elaboration of a law of universal gravitation. In addition to all this, it will also be argued that the conclusions achieved by Hooke in Of Spring may have also anticipated Newton's third law of motion.*

Keywords: *theory of Universal Gravitation; Hooke's law; spring; rule of nature*

Introduction.

In 1678, Robert Hooke (1635–1703) published a pioneering scientific book: *Lectures de Potentia Restitutiva or Of Spring: Explaining the Power of Springing*



Bodies. In it, we find important observations about different branches of science, such as mechanics, geology, and meteorology. In the first part of this text, Hooke presents us with what we now call Hooke's Law, duly substantiated by his experiments in accordance with the motto of the Royal Society *Nullius in Verba* (Tinniswood, 2019). After this, Hooke also uses observations from nature, such as volcanic eruptions and records of fossilized species as evidence that the Earth has changed over time in shape and composition, and that fossils are records of species that lived in other times, concluding that "nothing in nature is exempt from change and corruption" (Hooke, 1678, p. 50). These ideas are developed in greater detail in his *Discourse of Earthquakes*, published in the *Posthumous Work* in 1705¹. As Ellen Tan Drake has remarked (Tan Drake, 1966), in the *Discourse of Earthquakes* Hooke already presents gravity as essential to keeping the earth a globe.

The possibility of bodies moving due to forces of attraction and repulsion has been raised over time by various thinkers and has been accompanied by different theories or beliefs. In this paper, I will present the development of Hooke's ideas on this topic, especially those that are present in *Of Spring*.

Discussion.

The Law of Universal Gravitation is commonly attributed to Isaac Newton (1643–1727). Nevertheless, Robert Hooke made important contributions to the study of gravitation before Newton's publication of the *Principia*. The rivalry between Robert Hooke and Isaac Newton is well-known and has been extensively covered by several scholars (Gal, 2005).² These two figures lived in the same period, were part of the same circles, and, with different stances, also addressed the same problems. In 1687, Newton published his famous book *Philosophiae Naturalis Principia Mathematica*, where his Law of Universal Gravitation is propounded. Following this publication, Hooke protested that there is no acknowledgment of him in the book. Such an acknowledgment would have been fair since the two exchanged letters on gravity. Hooke had already published, in 1674, *An attempt to prove the motion of the Earth from Observations*, where he defined basilar principles towards a theory of gravitation. Newton's justification for the absence of Hooke's name in the *Principia* was that Hooke had only presented assumptions while he, Newton, presented the mathematical explanation of gravity (Westfall, 2007).

Newton's response is still controversial: firstly, because in science the mathematical explanation needs to be supported by a theory, and secondly, because Hooke is said to have arrived at a part of the mathematical explanation, which would make Newton's claim false. Richard Westfall concludes that Newton was influenced by a letter sent to him by Hooke, in which the latter presented his idea about the possibility of a reciprocal attractive force between the Sun and the planets that would be inversely proportional to the distance between the bodies (Westfall, 2007).

¹ These ideas are pioneering in the history of geology. James Hutton (1726–1797), considered the founding father of geology, only wrote about these issues one hundred years later. Ellen Tan Drake even calls Hooke the "true founder of the science of geology".

² Such as, Michael Nauenberg, Mary B. Hesse, Alexandre Koyré, Ofer Gal, Richard Westfall, Allan Chapman, Michael Hunter, Simon Schaffer, John Gribbin, P.J. Pugliese, among others.

Alexandre Koyré (1952) also highlighted this letter in 1952. If we look at the original correspondence, no doubt remains about this:

But my supposition is that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocall, and Consequently that the Velocity will be in a subduplicate proportion to the Attraction and Consequently as Kepler Supposes Reciprocall to the Distance. And that with Such an attraction the auges will unite in the same part of the Circle and that the nearest point of accesse to the center will be opposite to the furthest Distant. (Turnbull, 1960, p. 309)

Throughout Hooke's work, we can follow the development of his thought toward a theory of universal gravitation. In his *Micrographia*, Hooke presents for the first time the concepts of *congruence* and *incongruence*, which would be key concepts in the theoretical foundation of his theory of gravitation and which would be taken up again in *Of Spring*. Through experiments with liquids in very thin tubes, Hooke realized that there exist what we nowadays call adhesion and cohesion forces. These forces were defined by the author in terms of their affinity to the concepts of *congruence* and *incongruence*, which he defines as follows:

By Congruity, I mean a property of a fluid body, whereby any part of it is readily united with any other part, either of it self, or of any other similar, fluid, or solid body; And by Incongruity a property of a fluid, by which it is hindred from uniting with any dissimilar, fluid or solid body. (Hooke, 1664, p. 12)

The notion that there exist driving forces in nature which bring things together or move them apart takes us back to the ideas of Empedocles. In the 5th century BC, this philosopher provided us with one of the first analogies of attraction and repulsion ever recorded. The pre-Socratic philosopher presents love and hate – union and separation – as driving forces of nature: “And these things never cease their continual interchange, now through Love all coming together into one, now again each carried apart by the hatred of Strife” (Kirk, et. al. 2013, p. 287). Love and hate were for Empedocles the driving forces of the cycle of life, forces which are found in equal quantity in the cosmos. Also attributed to Empedocles is the idea that “Strife is at odds with the roots, but Love is in harmony with them”. With hate things repel each other and move away, with love they attract and move closer.

From a conceptual point of view, Empedocles's theory is close to the ideas of *congruence* and *incongruence* used by Robert Hooke to talk about the phenomena of attraction and repulsion in nature. The difference and the innovation of Hooke's theory lie in the fact that Hooke based his concepts on experiences and observations of the physical world – we have moved from philosophy to science. In Hooke's analysis of this phenomena, he continues to try to establish the causes of attraction and repulsion in nature. For this purpose, he first propounds the cause of *fluidity*, which he understands, as we can see below, as a “certain pulse or shock of heat”:

And that we may the better find what the cause of Congruity and Incongruity in bodies is, it will be requisite to consider, first, what is the cause of fluidness; and this I conceive, to be nothing else but a certain pulse or shake of heat. (Hooke, 1664, p. 12)

The author continues in this vein by then explaining what he understands as *heat*:

(...) for Heat being nothing else but a very *brisk* and *vehement agitation* of the parts of a body (as I have elsewhere made *probable*) the parts of a body are thereby made so *loose* from one another, that they easily *move any way*, and become *fluid*. That I may explain this a little by a gross Similitude, let us suppose a dish of sand set upon some body that is very much *agitated*, and shaken with some *quick* and *strong vibrating motion*, as on a *Milstone* turn'd round upon the under stone very violently whilst it is empty; or on a very stiff *Drum-head*, which is vehemently or very nimbly beaten with the *Drumsticks*. By this means, the sand in the dish, which before lay like a *dull* and unactive body, becomes a perfect *fluid*; and ye can no sooner make a *hole* in it with your finger, but it is immediately *filled up again*, and the upper surface of it level'd. Nor can you bury a *light body*, as a piece of Cork under it, but it presently *emerges* or *swims* as 'twere on the top; nor can you lay a heavier on the top of it, as a piece of Lead, but it is immediately *buried* in Sand, and (as 'twere) sinks to the bottom. (...) The first of these Examples manifests, how a body actually *divided* into small parts, becomes a *fluid* and the latter manifests by what means the agitation of heat so easily *loosens* and unties the parts of *solid* and *firm* bodies. Nor need we suppose heat to be anything else, besides such a motion; for supposing we could *Mechanically* produce such a one *quick* and *strong* enough, we need not spend *fuel to melt* a body. Now, that I do not speak this altogether groundless, I must refer the Reader to the Observations I have made upon the shining sparks of Steel, for there he shall find that *the same* effects are produced upon small chips or parcels of Steel by the flame, and by a *quick and violent motion*; and if the body of *steel* may thus melted (as I shew it may) I think we have little reason to doubt that almost *any other* may also. (Hooke, 1664, pp. 12–13)

When Hooke defines heat as “a very *brisk* and *vehement agitation* of the parts of a body”, he is already defining heat as “movement”. It is also noteworthy that Hooke attributed the driving force of particles to heat, which in his view is nothing more than “constant motion”.³ In *Micrographia* we can find a good introduction to Hooke's vibratory theory of matter, but it is in *Of Spring* that Hooke further developed his ideas on this subject. In 1678, Hooke gave us a further definition of *congruity* and *incongruity*:

By Congruity and Incongruity then I understand nothing else but an agreement or disagreement of Bodys as to their Magnitudes and motions.

Those Bodies then I suppose congruous whose particles have the same Magnitude, and the same degree of Velocity, or else an harmonical proportion of Magnitude, and harmonical degree of Velocity. And those I suppose incongruous which have neither the same Magnitude, nor the same degree of Velocity, nor an harmonical proportion of Magnitude nor of Velocity (Hooke, 1678, p. 7).

These definitions are consistent with those that Hooke presented in his *Micrographia*, but here the emphasis is given to the notions of harmony and velocity.

³ These conclusions are already backed by experiments, which may place Hooke as one of the predecessors of the ideas of Benjamin Thompson (1753–1814). In *An Inquiry concerning the Source of Heat which is excited by friction*, Thompson presents several experiments from which he concludes that it is possible to generate heat with friction or movement and that we can therefore infer that heat is related to motion. However, the author is not yet firm in his statement. Thompson shows in this text that he has a practical notion of how heat is produced with friction, but the theoretical formulation presented by Hooke is more refined.

In *Of Spring*, we can see that Hooke defines the congruent and incongruent behaviors of bodies according to their motion. In other words, Hooke tells us that bodies are congruent or incongruent depending on the harmony or disharmony of their behavior concerning other bodies. Hooke elaborates on these concepts in more detail in his vibratory theory of matter, in which body and motion are defined:

By Body I mean somewhat receptive and communicative of motion or progression. Nor can I have any other Idea thereof, for neither Extension nor Quantity, hardness nor softness, fluidity nor fixedness, Rarefaction nor Densation are the proprieties of Body, but Motion or somewhat moved.

By Motion I understand nothing but a power or tendency progressive of Body according to several degrees of Velocity (Hooke, 1678, p. 7).

The author also propounds that the entire sensible universe consists essentially of matter and movement, these two elements being interdependent. Given the above definitions of body and motion, Hooke then proposes that vibratory movement is a fundamental component of nature:

The Particles therefore that compose all bodies I do suppose to owe the greatest part of their sensible or potential Extension to a Vibrative motion.

This Vibrative motion I do not suppose inherent or inseparable from the Particles of body, but communicated by Impulses given from other bodies in the Universe (Hooke, 1678, p. 8).

Although the vibratory movement is not a constituent part of the body, it functions in interrelation with the matter, and matter exists in interrelation with a vibratory motion.

These definitions are the philosophical basis for Hooke's Theory of Universal Gravitation, which the author arrived at through experiments, namely his experiments with springs. By adding different weights to spring-suspended supports, Hooke measured how far the spring stretched depending on the different weights he had added:

Take then a quantity of even- drawn Wire, either Steel, Iron, or Brass, and coyl it on an even Cylinder into a Helix of what length or number of turns you please, then turn the ends of the Wire into Loops, by one of which suspended this coyl upon an nail, and by the other sustain the weight that you would have to extend it, and hanging on several Weights observe exactly to what length each of the weights do extend it beyond the length that its own weight doth stretch it to, and you shall find that if one ounce, or one pound, or one certain weight doth lengthen it one line, or one inch, or one certain length, then two ounces, two pounds, or two weights will extend it two lines, two inches, or two lengths; and three ounces, pounds, or weights, three lines, inches or lengths; and so forwards (Hooke, 1678, pp. 1–2).

In fact, by carefully observing the behavior of springs we realize that it seems impossible to completely stop their movement. A step, a breath, makes them vibrate as if this were their natural tendency. Hooke argues that motion is essential on both large and small scales, and that elasticity and vibration are connected. He also realizes that there are two fundamental types of motion: distancing and rapprochement, or attraction

and repulsion. These experiments, accompanied by his vibratory theory of matter, gave rise to Hooke's Law. But what exactly is Hooke's Law?

At the beginning of *Lectures de Potentia Restitutiva*, Hooke writes: "The Power of any Spring is in the same proportion with the Tension thereof: That is, if one power stretch or bend it one space, two will bend it two, and three will bend it three, and so forward" (Hooke, 1678, p. 1). After presenting this rule, Hooke tells us that we can test it ourselves using "steel, iron or brass" (Hooke, 1678, p. 1). Additionally, the author states about this rule that "Nor is it observable in these bodys only, but in all other springy bodies whatsoever, whether Metal, Wood, Stones, baked Earths, Hair, Horns, Silk Bones, Sinews, Glass, and the like" (Hooke, 1678, p. 4), ending with "And this is the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed, whether it be of Rarefaction, or Extension, or Condensation and Compression" (Hooke, 1678, p. 2). Hooke tells us that we can test his rule by using different materials and applying them to bodies of different constitutions. Here we might raise the question: how does Hooke know that this rule will work for all these bodies?

According to Hooke's experiments, we should use steel, iron, or brass as materials. Nevertheless, in his conclusion Hooke writes that his rule works for several types of bodies, mentioning bodies that are not usually regarded as elastic, for example, glass. Did the author replicate the experiment with other materials despite not having described it in this text? To answer these questions, let us see what the author writes further in the text:

From this it will be easie to make a Philosophical Scale to examine the weight of any body without putting in weights, which was that which I mentioned at the end of my description of Helioscopes, the ground of which was veiled under this Anagram, c e d i i n n o o p s s t t u u, namely, *Ut pondus sic tensio*.

This Scale I contrived in order to examine the gravitation of bodies towards the Center of the Earth, to examine whether bodies at a further distance from a Center of the Earth did not lose somewhat of their power or tendency towards it. And propounded it as one of the Experiments to be tried at the top of the Pike of *Teneriff*, and attempted the same at the top of the Tower of *St. Pauls* before the burning of it in the late great Fire; as also at the top and bottom of the Abby of *St. Peters* in *Westminster* though these being by but small distances removed from the Surface, I was not able certainly to perceive any manifest difference. I propounded the same also to be tried at the bottom and several stations deep Mines, and *Dr. Power*⁴ did make some trials to that end, but his instruments not being good, nothing could be certainly concluded from them (Hooke, 1678, pp. 5–6).

We can see by reading that Hooke's aim in presenting his Rule of Nature was to construct a "philosophical scale", something whose scope was broader than just the analysis of the characteristics of bodies (strictly) considered elastic. And now we might ask: are we talking about *elastic bodies* or *bodies* in general? Are we talking about *elastic force* or just *force*? Is this rule applied to particular cases or universally? If

⁴ Refers to Henry Power, author of *Experimental Philosophy* (1663)

Hooke's conclusions came from his experiments with materials like iron, steel or brass, how does he conclude that the same rule will apply to other materials, or even to the measurement of gravity as a force, as he thought it did? And what is the relation between the experiments with springs, the experiments on the top of St Peter's Abbey and a scale to measure gravitation?

If we go back and look some quotes from the text above: "From this it will be easie to make a Philosophical Scale to examine the weight of any body"; "This Scale I contrived in order to examine the gravitation of bodies towards the Center of the Earth"; "And this is the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed, whether it be of Rarefaction, or Extension, or Condensation and Compression", we can see that, by presenting his law, Hooke set out to find a way to measure gravity.

According to Hooke's cosmological ideas, everything is in constant motion, and body and motion are interdependent. It seems like Hooke was thinking of gravity as a giant spring and, in this way, it would be possible to use the same experiment as the one reported in *Of Spring*, but this time in high places, to measure gravity. We can thus deduce that Hooke tried to measure gravity at the top of St Peter's Abbey to compare it with the gravity at its base. Francesco Sacco tells us something pertinent about Hooke's Law in his recent book *Real Mechanical, Experimental – Robert Hooke's Natural Philosophy*. In it, Sacco argues that Hooke's Law, as it is known in classical mechanics, is not exactly what the natural philosopher was trying to formulate:

In Hooke's natural philosophy, "ut tensio sic vis" meant something different than what in classical mechanics is known as Hooke's law. The concept of elastic limit, for instance, is missing in Hooke's study of elastic bodies, and the mechanical model employed by Hooke is quantitatively incompatible with the law that still bears his name. Like Petty, Hooke thought that the law was just a form of a more general principle of matter (Sacco, 2020, p. 84).

It may seem to us that Hooke made a "leap" in his explanation because we expect to find in this text the law of elasticity as it is taught today, but Hooke's "elasticity" refers to a property of bodies that they should possess in accordance with his vibratory nature of matter. Hooke was not trying to define a *Law of Elasticity*, he was searching for a *Universal Law* applicable to all matter that could be used to create a scale for measuring all forces, and among them, the "force" of gravity. Let us go back to *Of Spring* and consult once more Hooke's definitions of body and motion:

By Body I mean somewhat receptive and communicative of motion or progression. Nor can I have any other Idea thereof, for neither Extension nor Quantity, hardness nor softness, fluidity nor fixedness, Rarefaction nor Densation are the proprieties of Body, but Motion or somewhat moved. By Motion I understand nothing but a power or tendency progressive of Body according to several degrees of Velocity (Hooke, 1678, p. 7).

For Hooke, "body is motion" and motion is a "progressive tendency of the body in different degrees of speed":

These two do always counterballance each other in all the effects, appearances, and operations of Nature, and therefore it is not impossible but that they may be one

and the same; for a little body with great motion is equivalent to a great body with little motion as to all its sensible effects in Nature.

I do further suppose then that all things in the Universe that become the objects of our senses are compounded of these two (which we will for the present suppose distinct essences, though possibly they may be found hereafter to be only differing conceptions of one and the same essence) namely, Body and Motion (Hooke, 1678, p. 7).

As Hooke states, “the particles composing all bodies owe the greater part of their sensible or potential extension to a vibratory movement”, that is, body and motion do not exist in isolation, they are counterbalancing each other. Based on this assumption, vibratory movement is, more broadly, a characteristic of matter. Domenico Bertoloni Meli calls this worldview a “pan-elastic cosmology” (Meli, 2006, p. 245).

Now we can see clearly why Hooke refers to various materials, including materials that are not considered, in common sense, as elastic, and why the author starts from experiments with springs to measure gravity: since vibratory motion is an inherent characteristic of matter, it would be present in all bodies, from the ones we touch to the ones we observe on the sky. Thus, the method used to measure the force exerted by a weight on a spring (and vice versa) could be used to measure the “force” or “power” of gravitation. Hooke used his experiments with springs to measure *forces*. Since Hooke considered gravity as a force, he should be capable of measuring it by adapting the methods reported in *Of Spring*.⁵

Another important observation that we can make from Hooke’s presentation of his Rule of Nature is that it is possible to compare it with Newton’s third law of motion. Let us consider Newton’s formulation of this law:

To any action there is always an opposite and equal reaction; in other words, the actions of two bodies upon each other are always equal and always opposite in direction.

Whatever presses or draws something else is pressed or drawn just as much by it. If anyone presses a stone with a finger, the finger is also pressed by the stone (Newton, 1999, p. 63).

Hooke writes something very similar in *Of Spring* when he tells us of his Rule of Nature and the experiments that demonstrate it: “The same will happen supposing the body (moved by Spring) to be proportionately heavy, and the powers of Spring the same with the former” (Hooke, 1678, p. 21). Let us now look at one of the experiments that Newton described during the discussion of his third law of motion:

I have tested this as follows with tightly wound balls of wool strongly compressed. First, releasing the pendulums and measuring their reflection, I found the quantity of their elastic force; then from this force I determined what the reflections would be in other cases of their collision, and the experiments which were made agreed with the computations. The balls always rebounded from each other with a relative velocity that was to the relative velocity of their colliding as 5 to 9, more or less. Steel balls rebounded with nearly the same velocity and cork balls with a slightly smaller velocity,

⁵ Note that Hooke already considers gravity as not only a terrestrial, but also a celestial, force when he says, in his *Micrographia*, that “(...) there is in the Moon a principle of gravitation, such as in the Earth” (Hooke, 1664, p. 245).

while with glass balls the proportion was roughly 15 to 16. And in this manner, the third law of motion – insofar as it relates to impacts and reflections – is proved by this theory, which plainly agrees with experiments (Newton, 1999, p. 60).

Hooke did not use the same words as Newton, namely that forces act in opposite directions, but his experiments with springs show that this is what occurs between weight/mass and force/spring. He also described the relationship between body and motion in the following way: “These two do always counterballance each other in all the effects, appearances, and operations of Nature” (Hooke, 1678, p. 7). Concerning his Rule of Nature, Hooke assures us that “this the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed”.

Both Hooke and Newton arrived at similar conclusions: the former used the distension of springs as a way of determining the elastic force and concluded that the force of the spring is proportional to the tension exerted; the latter, by using the separation of balls of wool as a way of determining the elastic force, concluded that the force exerted by the wool is equal and opposite to the tension exerted by the collision. While Hooke starts from a static system, Newton starts from a dynamic system, but the goal of both is to analyze and explain the force of gravitation, and both end up determining the “elastic force” in each of the cases presented. However, while Hooke claimed to have found a “Rule or Law of Nature”, Newton claimed to have found a “Law of Motion”. As Hooke published *Of Spring* in 1678, nine years before the publication of the *Principia*, it seems very implausible that Newton did not know of Hooke’s experiments. Note that Newton mentions several names throughout the *Principia*. Nevertheless, Hooke’s name is not mentioned, not even regarding the experimental determination of elastic force.

Beyond this, Hooke had already taken into account the law of inertia in his text *On the inflection of a direct motion into a curve by supervening Attractive principle* (1666). The law of inertia is commonly attributed to Newton, but, Descartes and Kepler, for example, already recognized and used this law. Christiaan Huygens (1629–1695) also stated it in *De motu corporum ex percussione*: “Hypothesis I: Any body already in motion will continue to move perpetually with the same speed and in a straight line unless it is impeded” (Huygens, 1977, p. 574). Besides referring to the law of inertia, Hooke also presents us with an experiment made with a pendulum in order to demonstrate the movement of bodies through the force of gravitation. If we look at this document, we can verify that, in 1666, two years after the publication of *Micrographia*, Hooke was developing a theory of gravitation. These developments would allow him to publish his *Attempt to Prove the Motion of the Earth* in 1674, where he states for the first time, in a succinct but very efficient manner, his principal assumptions for a theory of universal gravity:

At which time also I shall explain a System of the World differing in many particulars from any yet known, answering in all things to the common Rules of Mechanical Motions: This depends upon three Suppositions. First, That all Celestial Bodies whatsoever, have an attraction or gravitating power towards their own Centers, whereby they attract not only their parts, and keep them from flying from them, as we may observe the Earth do, but that they also attract all the other Celestial Bodies that

are within the sphere of their activity; and consequently that not only the Sun and Moon have an influence upon the body and motion of the Earth, and the Earth upon them, but that also (...) by their attractive powers, have a considerable influence upon every one of their motions also. The second supposition is this, That all bodies whatsoever that are put into a direct and simple motion, will so continue to move forward in a streight line, til they are by some other effectual powers deflected and bent into a Motion, describing a Circle, Ellipsis, or some other compounded Curve Line. The third supposition is, That these attractive powers are so much the more powerful in operating, by how much the nearer the body wrought up on is to their own Centers. (Hooke, 1674, pp. 27–28)

Also in his *Attempt*, Hooke describes an *experimetum crucis* to prove the Copernican hypothesis, namely by measuring the parallax of a fixed star (Hooke, 1674). When we consider the findings contained in these texts and in *Of Spring*, Hooke's contributions toward a theory of universal gravitation become undeniable.

Many scholars have wondered why Hooke was overlooked in comparison to Newton and opinions diverge. On one hand, Steven Shapin states that the main reason for the dismissal of Hooke's contributions lies in the fact that Hooke was from a lower social status, closer to the craftsman category than to the gentleman category to which, for example, Newton and Boyle belonged (Shapin, 1989). On the other hand, Ellen Tan Drake thinks that this does not explain what happened with Hooke. Tan Drake states that Hooke had, in fact, an important social status in his time and that it was the adulation of Newton that placed Hooke in his shadow, alleging that Hooke still suffers from bad press today (Tan Drake, 1966). Lisa Jardine, Hooke's biographer, also questions what happened to Hooke's reputation after his death that led him to be forgotten in a matter of few years. Jardine highlights some plausible factors: the decrease in reputation caused by his self-isolation and illness in the years before his death; the battle for his fortune after his death, which led to a dispersion of his legacy among people who did not love him, and, consequently, did not deal with his belongings properly; and the possible conspiracy of Isaac Newton, who assumed the position of President of the Royal Society after his death (Jardine, 2004). It seems to us that the arguments of Ellen Tan Drake and Lisa Jardine are the most reasonable. Regardless of what led to Hooke staying in Newton's historical shadow for such a long time, it is clear today that Hooke did contribute decisively to the creation of a theory of universal gravitation and that we should, using Ricoeur's words, give him "a burial, a place in the collective memory" (Ricoeur, 2004, p. 350).

Conclusions.

Taking all of this into account, we can establish the following conclusions: Hooke's Law, as we understand it today, is not exactly what Hooke was trying to formulate. Hooke intended to find a scale to measure forces, or what the author calls a "philosophical scale", whose purpose would be to measure gravity. Through his experiments with springs, Hooke came to understand the relationship between force (deformation). We can also infer that, in his experiments with springs, Hooke was already close to determining a gravitational constant. His attempts to measure the force

of gravitation were not successful, as the author tells us “(...) because these places were at small distances from the surface, I was unable to observe any clear difference. I proposed that the same should be done at the bottom of some mining stations, and Dr. Power even made some experiments in this direction, however, as the instruments he possessed were not of good quality, nothing could be concluded from his data.” We can thus conclude that, in *Of Spring*, Hooke was searching for an experimental, mathematical, and philosophical understanding of gravity. We can also observe that, as Centore also notes (Centore, 1970), for Hooke gravity was a mechanical (not animistic) force. Despite that, we can also find in *Of Spring* an anticipation of Newton’s third law of motion.

This paper presents the possible contribution of an author, namely Robert Hooke, to the creation of a Law of Universal Gravitation, specifically at the time when he presented his Rule of Nature (Hooke’s Law), which was created to analyze gravity. From a historical perspective, we can observe that the Law of Universal Gravitation created during the 17th century was the product of a period in science to which several authors contributed (Hecht, 2021).⁶ We cannot attribute the Law of Gravitation merely to Newton and, in association with his name, give it the title of “discovery”. This law was a product of philosophical and scientific discussions that began with names like Descartes, Huygens, Borelli, Kepler, Gilbert, Boulliau, Galileo, Roberval, Horrocks, and Hooke, among others, and continues until today. By focusing on Robert Hooke’s contributions to the evolution of this law, we can show that science is made of layers and that Newton’s mistake was that he wanted to keep the *apple of Discord* for himself. Newton was not standing on the shoulders of giants, but on the shoulders of all those who contributed to science, regardless of their size or social status.

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⁶ Hecht (2021) has an enriching article on this topic.

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Про природу Закону Гука

Анотація. “Пояснення Сили Пружних Тіл” (1678) – важлива книга для історії науки. Ця книга більш відома завдяки презентації Гуком закону, який носить його ім’я. Цей закон, або “Правило природи”, як стверджує автор, зазвичай викладають у контексті аналізу пружних тіл та їх деформацій. Однак рамки, в яких було введено цей закон, виходять за межі контексту, у якому його зараз викладають. Поряд з представленням експериментів Гука з пружинами, автор створив свою вібраційну теорію матерії, в якій поняття конгруентності та неконгруентності, спочатку представлені в його “Мікрографії” (1665), будуть визначені більш детально. Ці концепції мали на меті теоретично обґрунтувати рухи тяжіння і відштовхування в природі. Ця стаття має на меті ще раз вивчити “Пояснення Сили Пружних Тіл”, щоб краще зрозуміти думки Гука про правило, яке носить його ім’я, і його концепцію гравітації, яку автор вважав силою. Тут будуть представлені визначення тіла та руху Гука, а також його фактична мета, коли він сформулював так званий закон Гука. Як ми побачимо, Гук мав намір створити “філософську шкалу” для вимірювання гравітаційного тяжіння між тілами. Беручи до уваги його попередні публікації, такі як “Спроба довести рух Землі за допомогою спостережень” або “Мікрографія: деякі фізіологічні описи дрібних тіл”, або навіть неопубліковані роботи, такі як “Про перегин прямого руху в криву за допомогою принципу притягання”, стає зрозуміло, що Гук відкривав шлях до розуміння гравітації ще до того, як було опубліковано “Начала” Ньютона (1687). Беручи до уваги суперечку між Ісааком Ньютоном і Робертом Гуком, ми також маємо намір зміцнити ідею про те, що Гук зробив незамінний внесок у розробку закону всесвітнього тяжіння. На додаток до всього цього, також буде стверджуватися, що висновки, зроблені Гуком у “Пояснення Сили Пружних Тіл”, можливо, також передбачали третій закон руху Ньютона.

Ключові слова: теорія всесвітнього тяжіння; закон Гука; пружина; правило природи

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The contributions of Jane Addams on the development of occupational therapy

Abstract. *In 1915, the first occupational therapy school was founded by Jane Addams at Hull House (Chicago, USA). In that process, Addams inspired the first generation of occupational therapists, especially Eleanor Clarke Slagle. Thus, this article seeks to highlight the contribution of Jane Addams to the development of Occupational Therapy through an in-depth bibliographic review, from primary sources. Thereby, this article is divided into two parts. The first part explores the relationships within the foundation of occupational therapy at the Hull House, in the early twentieth century. In this context, female vindication in the United States started when middle-class women began to carry out a series of public activities, which separated them from their traditional roles. As a result, the relationships and influences between the residents of the Hull House and the first occupational therapists in Chicago were identified. The second part takes into consideration some reflections on some Jane Addams influences in the development and current identity of occupational therapy, mainly in one of its collaborators, Slagle. Jane Addams was a role model for many of the first occupational therapists, especially for Slagle. She learned from Addams her tenacity and leadership skill, central aspects for the first school of occupational therapy foundation. Also, Addams, as a pragmatism philosopher, extended ideas that prioritizes practice by theory, not in a segmented dichotomy, but from a holistic perspective, through which each one is constantly presented, which gives the basis of doing and knowing as professionals in the occupational therapy field. On the other hand, pragmatist conceptions invite us to create a reality consistent with the maximum utility of the ideas and beliefs of our society. Some of these aspects are valid in the current practice of occupational therapy. Today, more than 100 years after its foundation, occupational therapy has much to learn yet, from the philosophy of Jane Addams.*

Keywords: *history of science; pragmatism; professional identity; progressive era; United States of America*



Introduction.

Jane Addams philosophy is not widely known in the training of occupational therapists in Latin America (Colegio de Terapeutas Ocupacionales de Chile et al., 2015; Morrison, 2016a; Morrison, 2016b; Morrison, 2022). However, there are different elements that are highly relevant and that relate to the foundation of the profession that is inspired by her philosophy and figure. Therefore, this article, written by a Latin American author, has reviewed ancient writings and other texts related to the origins of occupational therapy, and has set out the objective of recognizing in Jane Addams an exemplary and crucial figure in the constitution of the profession. And therefore, a character necessary to publicize in the formation of the discipline.

For this purpose, this paper will be divided into two parts, the first exploring the relationships within the foundation of occupational therapy at the Hull House, in the early twentieth century in Chicago. For this, an in-depth bibliographic review was used, from primary sources, identifying the relationships and influences between the residents of the Hull House and the first occupational therapists in Chicago.

Jane Addams was a role model for many of the first occupational therapists. Thus, the second part considers some reflections on some Addams influences in the development, practice, values and current identity of occupational therapy. This reflection focuses mainly on one of her collaborators Eleanor Clarke Slagle, who would have worked closely with Addams.

First part: Foundation of occupational therapy at Hull House.

The Chicago Civic and Philanthropy School was supported by a group of women belonging to one of the most influential social settlements of its time, the Hull House. This place was founded by Jane Addams and Ellen Gates Starr in 1889. Many influential women of the time such as Julia Lathrop participated in its operation. Many young women, mainly driven by the feminist movement, participated in this place (Addams, 1912). This place is very relevant, since Eleanor Clarke Slagle founded the first vocational school of occupational therapy in 1915. But, to understand this milestone, it is necessary to review the influences that allowed women to think that their work could be formalized in a context where androcentrism was present.

Addams, Starr, Lathrop and Slagle belonged to the first generation of women who exchanged "volunteering" for professional work. Women who worked without compensation began to leave their homes and managed to validate their professional activity by giving them a place in society. This happened in the feminist context of the time.

In the so-called second wave of feminism, between the end of the 19th century and the beginning of the 20th century (Freedman, 2003), political actions were directed towards more than the achievement of the right to vote for women. The change of the legislation, the economy and the society itself was sought (Miranda, 2007). Women sought the emancipation of the male yoke and end inequality between gender roles.

Thus, female vindication in the United States was accentuated in the mid-nineteenth century, when middle-class women began to carry out a series of public activities, which separated them, little by little, from their traditional roles (Quiroga,

1995). This movement was gestated along with the development of the Industrial Era and to the extent that the *rural Christian Era* began to be replaced (Metaxas, 2000).

When Addams and Starr founded the Hull House, the social settlement considered “the heart of women's reform in Chicago” (Quiroga, 1995, p. 37), this institution contributed to the political, professional and labor training of many women, in addition to provide support to hundreds of families, mainly immigrants, in the context of the industrial era (Addams, 1912; Addams, 1916; Knight, 2005; Kuiper, 2010; Miranda, 2007). And one of the objectives of the Hull House was to create a bond between women, and some progressive middle-class men with groups of poor people and immigrants, who were part of the industrialized city of Chicago (Addams, 1912).

In charge of Addams the Hull House led the movement of social settlements in the United States, and expanded the domain of “the feminine” redefining new roles for thousands of women, who began to leave more and more of their homes (Wade, 2005). In 1911, there were 215 social settlements, and 53% were female only (Quiroga, 1995, p. 35). This motivated many women to take on new roles and empower themselves in the face of social reforms in the country.

In this process the pragmatist philosophy was an important and constituent ideology of the Hull House and the entire progressive movement that would have found the occupational therapy. The feminist movement and its objectives of vindication of women found a theoretical support in pragmatism, which promoted constant reflection on the notions of truth; in turn, pragmatism found in the Hull House the “start-up” of many of its ideas about social transformation. Many pragmatists at the University of Chicago, including John Dewey and George Herbert Mead, put their ideas on social change and reforms into practice at Hull House, thanks to Addams and Lathrop.

The Hull House, in addition to being the main center of pragmatism operations, was a meeting point for other ideologies and movements that would lead to what we know today as occupational therapy.

In 1897, *the Chicago Arts and Crafts Society* was founded, organized in the Hull House by Rabbi Emil Gustave Hirsch and Julia Lathrop, in response to the diseases generated by the industrial revolution (Breines, 1986a; Breines, 1986b; Breines, 1992; Metaxas, 2000). Since then, a series of artistic and craft began to be studied as a way to resist the industrial era, seeking to achieve one of the objectives of the Society: to recreate the ideal of artisans (Quiroga, 1995). The arts and crafts movement sought to reposition the value of artisanal work in the industrialized era at the beginning of the twentieth century (Hopkins et al, 1998) humanized work and the activities carried out by workers.

Social activists, aligned to pragmatism, claimed that the occupation was a means to promote and restore health (Breines, 1986a), so many workshops were opened in the community in specific areas, such as pottery, metal, glass, wood and textile products. Craft work would provide opportunities for the working class to experience productive and meaningful activities, preventing and fighting against alienation generated by the industrial era and modern life (Quiroga, 1995).

Addams and Lathrop, as well as Dewey and James, believed that education was essential to change social or inequality situations, so they founded a museum in the

Hull House to instruct and educate different citizens about the importance of craft work (in opposition to industrial work); in this way, “a continuous reconstruction of the experience” would be favored (Quiroga, 1995, p. 41).

Julia Lathrop who, in addition to belonging to the Hull House, worked in arts and crafts, was one of the first to relate this movement to Mental Hygiene. She sustained the need to reform treatments for people with psychiatric illnesses, so her ties with the director of the Chicago Civic and Philanthropy School led to different courses on occupations, occupations and mental health. From this perspective, more than just an “influence”, the arts and crafts movement is crucial for the development of occupational therapy, mainly because of its political actions.

Lathrop can be considered, along with Addams, as one of the most unknown female figures for the official history of occupational therapy. In the Hull House, thanks to the contributions of Lathrop (Addams, 1935) and Addams (Breines, 1986a; Breines, 1986b; Breines, 1992) occupational therapy began to develop, which took special force when Eleanor Clarke Slagle (Quiroga, was integrated) nineteen ninety-five).

In 1893 Lathrop met Adolf Meyer (psychiatrist and recognized as one of the founders of occupational therapy) and invited him to join the Hull House and support his social causes. Meyer, who was 26 years old at the time, is very surprised to meet Jane Addams. Lathrop and Meyer formed a strong alliance to respond to the criticisms of the time about the absence of “science” in the “new methods” used in psychiatry (Addams, 1935). This may have been one of Meyer's main motivations to begin investigating the relationship between occupations and the balance in people's lives.

Lathrop contributed to many of these investigations to examine how mental health interventions are performed and the development of social programs. Due to these works, which are generally ignored by the official history of occupational therapy, attributing only theoretical development to Meyer.

Lathrop continues to work with Addams, Dewey and other members of the Chicago Civic and Philanthropy School where a social work program was offered that lasted two years and chaired by Graham Tylor (1851–1938) (also had the influence of Clifford Beers, with whom she was on the National Mental Hygiene Committee). Thus, as Lathrop and Hirsch introduced a training course in occupations as we noted earlier.

Taylor, the director of the School, and very close to Lathrop and Addams (Deegan, 2005, p. 114), convinced the state hospital to finance the special course of Healing and Recreational Occupations, which was aimed at nurses and staff linked to the health area. One of the innovations of this course, in addition to the methodology, was the abandonment of the term “custody” concept used for long years towards the patients, for a new one: education (Quiroga, 1995, p. 50). For the development of occupational therapy in the hands of Slagle this course developed at the Hull House would be central.

When she was 34, Slagle began studying social work, a career taught at the Hull House, being her mentors Addams, Starr and Lathrop, among others and other important representatives of the “social school” of Chicago (Frank, 1992; Loomis, 1992; Suzuki, 1982). Here, I would begin to take a series of courses based on

therapeutic occupations and be closely linked with the women of the Hull House. This link led her to lead a group of students in a summer course “Occupations for the sick” in New York in 1909¹ (Slagle, 1936).

However, it was in 1911, when she was about 40 years old, that she began to be interested in health reform driven by the mental hygiene movement. Advised by Addams and Lathrop, Slagle takes the course “Curatives occupations and recreations” at the Chicago Civic and Philanthropy School, belonging to the Hull House and taught by Julia Lathrop and Rabbi Emil G. Hirsch (Bing, 1981; Metaxas, 2000; Frank, 1922; Kielhofner, 2009; Pollard, Sakellariou, & Kronenberg, 2009; Sanz & Rubio, 2011). The methodology of this course was very innovative for the time, the students learned through theoretical readings and received training in trades, as well as clinical experience. Also, she sought to teach how occupations allowed the muscles and mind to work together, which was reflected through games and exercises. This course had been taught since 1908 and was aimed at both nurses and hospital assistants and was supported by Adolf Meyer (Addams, 1935; Loomis, 1992; Quiroga, 1995).

When she finished the course, Slagle worked in different hospitals in Michigan and New York where she organized, executed and subsequently analyzed her re-educational classes for people with serious mental illnesses. These classes, which were considered a type of treatment through activities, were created by incorporating the knowledge of Lathrop and other mentors. Therefore, together with her excellent performance and outstanding participation, in 1912 she administered the fifth session of the course (Loomis, 1992).

Little by little, the recognition for her work in the application of occupations as an educational treatment was growing, and her contact with the leaders of the mental hygiene movement and recognized characters who spoke about the “therapeutic occupations” was increasing. Her innovative method of reeducation led her to lead the first department of occupational therapy in Baltimore at the Henry Phipps Psychiatric Clinic of Johns Hopkins Hospital, led by Meyer (Breines, 1986a; Metaxas; 2000, Quiroga, 1995; Suzuki, 1982).

Meyer, who had been attending the Hull House for a while, asked Lathrop for a person to help him organize the city's first occupational therapy department. Lathrop, without hesitation, urged Slagle to work with him (Loomis, 1992). Later Meyer would point out that Slagle was a model in the service of occupational therapy (Meyer, 1937).

Working with Meyer, she developed the first method of occupational therapy intervention, training in habits, which sought a balance between work, rest and play.

¹ It is unknown what Slagle's first link with the Hull House was. Most documents indicate that she did a first course with Lathrop and Addams in 1911 (Bing, 1981; Metaxas, 2000; Frank, 1922; Kielhofner, 2009; Pollard et al., 2009; Sanz & Rubio, 2011), but Slagle refers in a 1936 document (a) that led a group of students to New York to take a course with Julia Lathrop in 1909. It is strange that she was not part of this course, either as a student or instructor. Most likely, since her integration into the Hull House she was in constant training in “therapeutic occupations” and formally enrolled in the course of 1911. In another document of 1934 (c) she states that “the School of Civics and Philanthropy from Chicago, in 1908-1909, she gave a summer course in occupational therapy and recreation, which seems to have been the first in this field” (p. 291). But it is not clear if she participated in the course, or at what level it was linked, or if it is the same course referred to two years later.

This method was based, in part, on the theoretical foundations of the pragmatism of Addams, James, Dewey, Peirce and Mead, from their theorizations about habits, demands of the environment, creativity and experience within their meanings for individual change and social (Bing, 1992; Breines, 1986a; Breines, 1986b; Kielhofner, 2009; Loomis, 1992; Pollard, Sakellariou, & Kronenberg, 2009; Sanz & Rubio, 2011; Suzuki, 1982). In this way, Meyer recognized her as the first to systematize a method of training in occupations during her stay at the Psychiatric Clinic, applying a systematized activity in the pavilions of an institution. Also, he pointed out that his proposal to combine clinical work with visits to the homes of patients was very helpful for his theories (Meyer, 1922; Meyer, 1937). In addition, during the period in which Slagle remained at the Meyer institution, it began to be valued as the first elite hospital of medicine in the United States, becoming a model for hospital center recommendations (Frank, 1992).

Slagle significantly improved her methods by working with Meyer. Her technique was aimed at “reeducating” patients with chronic diseases and sought the development of new “decent”, “worthy” and necessary habits for life; as well as the substitution of harmful habits within an individualized program, whereby new ways of replacing these habits for “better” ones or those that benefit health (Slagle, 1944) were investigated.

While working with Meyer for two years (1912–1914) (Bing, 1981; Bing, 1992; Frank, 1992; Sanz & Rubio, 2011), she began to interact with a well-known psychiatrist, William Rush Dunton, and with his wife Edna Dunton, a who visited frequently² (Suzuki, 1982). Thus, they began to formulate the idea of organizing an association that promoted the use of occupations as a treatment, so, and following the division of gender roles of the time, Dunton worried about being a spokesman and diffuser through scientific articles, books and papers at medical conferences explaining the theoretical relationships between occupational therapy and psychiatry, including Meyer's theoretical contributions; while Slagle was responsible for increasing their clinical experience and promoting occupational therapy through women's social networks, formal institutions and at the political level, and conducting different consultations to Dunton at the Sheppard Pratt Institute on occupation, in addition to publishing different writings, from scientific articles (Breines, 1986a; Quiroga, 1995), conference proceedings, editorials, and government reports to bibliographic reviews.

In 1913 she attended the Maryland State Conference on Mental Hygiene meeting, where she met again with Graham Taylor, director of the Chicago Civic and Philanthropy School, whom she met at the Hull House. Taylor, after visiting the clinic in which Slagle worked, said he was “amazed”, an assessment that he would transmit in a letter to Julia Lathrop, indicating that there was mixed “work, science and sympathy” (Taylor, 1913 in Quiroga, 1995, p. 46). Slagle suggested to Taylor and Lathrop (who was the vice president of the School in that period) the importance of the continuity of the course that both taught, arguing that in the coming years the demand

² Slagle and Dunton would have met at a meeting of the American Medical-Psychological Association in Baltimore (Quiroga, 1995; Sanz & Rubio, 2011).

for professionals trained in occupational therapy would increase considerably (Quiroga, 1995).

Thus, Taylor saw the importance of occupational therapy in mental health, but also in its possible applications in the prevention and treatment of people with tuberculosis. As a result, in 1914, he invited Slagle to return to Chicago to give a series of lectures on occupational therapy at the School of Civics and Philanthropy. Thus, she began to participate, full time, in the expansion of occupational therapy and mental health reform movements, integrating herself into the mental hygiene movement (James, 1971; Metaxas, 2000; Pollard, Sakellariou, & Kronenberg, 2009; Quiroga, 1995).

Under the support of the Illinois Society for Mental Hygiene, Slagle began teaching community workshops for unemployed people with chronic diseases to strengthen their occupational skills. Initially, the Experimental Station as the workshop was called, was aimed at people with chronic mental illness; However, the demand grew considerably, so the workshop was opened to people with different degrees of physical disability and personality disorders, among others (Pollard, Sakellariou, & Kronenberg, 2009; Quiroga, 1995; Sanz & Rubio, 2011).

Finally, in 1915, integrating the feminist movement, pragmatism and Addams influences, Slagle would found the first professional school of occupational therapy in the United States, belonging to the Hull House and under the jurisdiction of the Illinois Mental Hygiene Society and the support of Jane Addams (Breines, 1986a, Gordon, 2002; Pollard, Sakellariou, & Kronenberg, 2009; Sanz & Rubio, 2011). Thus, Slagle would be known as: "Jane Addams of occupational therapy" for her great contributions to the profession (Metaxas, 2000; Quiroga, 1995).

This first school, The Henry B. Favill School of Occupations was established in the occupational department of the Illinois Mental Hygiene Society and in 1917 this School was named after Dr. Favill, a Chicago physician who worked in preventive medicine, public health and civic reform. In addition, she was the first vice president of the Society and supported the constitution of the occupational department (Loomis, 1992; Pollard, Sakellariou, & Kronenberg, 2009).

Under the direction of Slagle, the courses of the School began to incorporate contents of medical instruction, physiology, psychology and sociology, at the same time as arts, crafts and physical recreation. Its objective was to train students for work with people with mental and physical illness, disabled soldiers and school-age children with learning disabilities (Slagle, 1934a). It followed the particular style of the Hull House, which was unique. In addition to training professionals, she was dedicated to helping people with disabilities through their workshops. These workshops worked during the time that the School offered professional training.

Dunton noted that the School was the best place in the United States to train occupational therapists, who served as assistants in post-war reconstruction. He also indicated that the other schools that appeared later, such as those in Boston, Philadelphia or New York, took as an example the one that Slagle founded. The School trained virtually all "reconstruction aides" in the Midwest under the direction of Slagle.

Observing the evidence of the work, the Mental Hygiene Society began to be interested in the role of occupational therapy for patients with tuberculosis³. Thus, their programs were complemented, both in training for people with physical, mental illness, work with disabled soldiers, as in the treatment of children with disabilities of school age (Pollard, Sakellariou, & Kronenberg, 2009). Together with men and women involved in the mental hygiene and tuberculosis movement and with philanthropist women's groups, who financed their projects, Slagle made alliances with physical rehabilitation hospitals, clinics and psychiatric hospitals, and with many nurses, among which her relationship with Susan Tracy (Metaxas, 2000), in order to extend the novel occupational therapy.

Slagle remained in Chicago for some years (until 1922), dedicating herself to creating contacts with other cities, where different people began to argue that this “new therapy” could constitute an autonomous professional field (Quiroga, 1995, p. 52). Thus, it was the basis for the organization of the foundation of the profession in 1917. Together with Dunton, they met a group of professionals in Clifton Springs (New York) and welcomed other doctors and activists who supported occupational therapy, like Herbert Hall, George Barton and Meyer (Pollard, Sakellariou, & Kronenberg, 2009, p. 124).

Part Two: The Jane Addams effect on the values and identity of occupational therapy.

Some learning about Jane Addams' philosophy, applied to occupational therapy, is expressed in different ways.

From the proposals of the interclass spaces, occupational therapy has considered diversity as one of its core values. This aspect has been valued since the creation of the discipline in the Hull House. In this sense, Addams was hardly criticized for validating, in the same way, the opinions of migrant women as important representatives of the city, because she considered that the power of democracy involved listening to those who had no voice in all the processes of taking decisions.

This is linked to lateral progress. Concept that has allowed us to understand social development from an ethical and mutual perspective.

Jane Addams has invited us to understand that it is possible to build realities from the social questions of what we have been told reality is. From their perspective, it is possible to reflect and criticize the “given reality” to propose alternatives, always from their social ethical perspective.

For Addams, the truth is a social construction that obeys rules agreed by people and that they develop based on problems, so they should not, in any sense, stay, if it is obstructing the development of society (Addams, 1899).

He understood that social inequalities represented learning and habits rooted in society, which, with effort, could be modified (Addams 1902, 1916). This has been another of the central elements for the practice of occupational therapy since, from the

³ Where the occupation was applied to teach guidelines in the daily routine, which helped in the improvement of patients.

beginning, the first therapists began to work with displaced people excluded from society, and with whom “no one else” wanted to work. An example of this is Slagle's work in psychiatric hospitals, where she managed to advance in an occupational treatment for patients who had unfavorable prognosis.

Along with these lines, the proposals for social reconstruction are central to the values of occupational therapy. Understanding that social segregation can be understood as an established belief as much as a habit, following the logic of pragmatism, it is a basis for understanding what can be modified, in the way we question them and stop taking them for granted.

In this sense, inequality, from their perspective, occurs when a small group imposes its truth in a non-democratic space. Therefore, the development of a dialogue and active listening, apart from a comprehensive understanding, is central to the processes of social transformation. Perhaps, this is one of the most consistent elements that occupational therapy has inherited from its vision, since the way in which the profession has been related to its patients establishes that premise as a foundational condition. For example, from a perspective that involves social ethics, occupational therapists have learned active listening, without making value judgments, refining our conceptions of “good or bad” a priori.

Addams suggested that there is no single religious or moral truth, but there is consensus and ethics that should focus on the mutual benefit of social classes and individuals (Addams, 1895, pp. 183–204). This has been expressed in the ways that occupational therapy has developed its world view.

In Addams's proposal, theorizing and putting into practice, and vice versa, was a recursive, dynamic and constant process, since it was of no use just theorizing without making a real contribution to society. This is another aspect that occupational therapy has taken into account.

Another of the central aspects is her radical pragmatism, expressed in her support for the labor movement, in the feminist revolution of the time and in the pacifist movement. Many occupational therapists were trained in this context, observing how Addams was able to gather large masses of people and fight for the rights of people.

Following the above, there are principles that guided its practice, among them: teach by example, practice cooperation and practice social democracy (Addams, 1912).

In another of her writings, Slagle notes that Jane Addams and Julia Lathrop were important figures and pioneers in social work and in the usage of therapeutic occupations. And that occupational therapy programs had a great development in Illinois thanks to the two of them along with Adolph Meyer (Slagle, 1936). The latter would have been the influential one for the occupations to be applied more and more into clinical settings (Slagle, 1934c).

Addams' example led to Slagle worrying about valuing women's work. She never hesitated to make public recognition in her role as a speaker (Slagle, 1929), and invited them to integrate into the world of work. Initially, she suggested that older women were the most suitable for working with mental patients (Slagle, 1922), with time she would broaden her gaze towards younger women and men (Slagle, 1936). Concluding that the most relevant is the responsibility and take the great weight that means working with

other people, and not only the skills you have, but the character and understanding the behavior as symptoms in a scientific way.

Thus, she would defend the formation of women groups, indicating that many have proven to be brilliant, always to be alert and that they have developed excellently in the clinic receiving many gratifying compliments for their intervention in hospitals. In addition, thanks to them, occupational therapy is being more recognized, Slagle (1934a) said.

For pragmatists, a theoretical thought is political per se. An ideal must be justified from theory, practice, and above all, from social action. Addams' approaches are an example of this. Her type of pragmatism is linked to a political and social movement and has great similarities with Slagle. Both women, pioneers in their respective fields of action, performed critical reflection and practical application as a whole, away from the theory / practice dichotomy.

Addams served as an example for Slagle in two aspects, first as previously reported, as a female figure with power and leadership characteristics; and second, to build an epistemology based on one's experience. And it is that both women combine in their writings: life experiences with philosophy and social movements. Addams' social ethics and life experiences influenced all of Slagle's theoretical practice and development.

According to Addams (1902), social ethics is achieved to the extent that citizens take charge of it. Slagle knew this, so her occupational therapy sought to validate people with mental illness as members of society “people”, which was not considered at that time. As for Dewey, James, Mead and Peirce, for Addams, habits are responsible for human behavior and especially for social inequalities (Addams, 1902; Addams, 1916).

The integration of people with mental illnesses and other disabilities into society is the way through which Slagle approaches Addams' social ethics, contributing to the change in the “ideas / habits of truth”. For Addams (1895) the expression and visibility of minorities contributes to social equality, facilitating respect and dignity in society. Slagle advocates the integration of people with mental illness promulgating Addams radical pragmatism.

Addams' radical pragmatism that defies established power structures, changing social reality, is one of the characteristics of Slagle's exercise. Thus, she denied the option that patients lived in degrading conditions, which she argued, led to types of behavior that disturbed the structure of their personality (Guillette, 1973, pp. 51–130). This is why she promoted their social adaptation defending their rights and dignity, from the pragmatic foundations of equality and respect and under the possibility of the permutability of ideas. For both Slagle and Addams, the practice is a priority for social equality and will be the one that nourishes and sustains the theory, as well as the development of new habits will favor social equality.

Slagle defended the rights of children (Slagle, 1934b) and struggled to eliminate back yards, that is, hospital rooms where patients with unfavorable diagnoses were kept (Slagle, 1922); she also used the concept of “habilitation” instead of “charity” (Breines,

1986b) and ideas also adopted by the activists, regardless of their faith and that in their usual practices they used therapeutic occupations and sought social equality.

In one of her writings, Slagle (1936) asks about the challenges of occupational therapy in the social context. It addresses the gender perspective to ask if all women (their patients) are satisfied with their life and domestic work or in “the field of sewing”, wondering if the occupations that are being used are the most suitable for them.

In this way, she continues to wonder what a sick person is. If a sick person is equal to someone unhappy, and if this is so, how different are they from the hospital patients to an ordinary person? And what would happen if they were replaced by “normal people”? Are there any differences? Slagle wonders what we consider “normal” or not, questioning the reality and established structures, and suggesting that occupational therapy can take care of these issues.

In her professional performance she was able to realize that when working with people with mental illness, the prejudices quickly dissipate, and it can be seen that they are “people like any others”, and that many of the prejudices of society are those that limit their integration. Thus, the occupations employed from a gender perspective are also questioned, implicitly arguing that the most relevant thing is how a person is happy doing the occupation she wants, and not an occupation imposed without considering their opinion.

These approaches, which are the basis of current occupational therapy, make us recognize Addams and Slagle as two of the most relevant women in disciplinary development and value their life and work, recognizing the influence of pragmatism in their occupational therapy.

Discussion.

Addams and Lathrop were two exemplary women for many occupational therapists who followed suit and observed that there were female models that could influence public policies, contribute to social reforms and make theoretical developments in different areas of knowledge.

Occupational therapy was formulated as a product of the intersection between a series of social movements and ideologies, such as the arts and crafts movement and mental hygiene. At first, teaching arts and crafts to people with mental illness meant that the occupational therapist should possess skills as an educator (Johnson, 1919; Slagle, 1936), as well as knowledge of nursing and health care (Tracy, 1910). All this suggested that the profession was oriented towards a new generation of professional women (Metaxas, 2000).

From this perspective, the arts and crafts movement plays a central role in the development of therapeutic occupations. The first occupational therapists treated many patients with neurasthenia (a feeling of exhaustion caused by excessive work and overpopulation). Thus, occupational treatment was linked to the arts and crafts and when scientifically based, occupations began to be understood as “therapy”, and not

only as “treatment”⁴ (Gordon, 2002; Laws, 2011). Along with the publications of medical men, pragmatist women, social workers, nurses and educators, were responsible for expanding occupational therapy throughout the country, which had an exponential boom when World War I broke out (1914–1918).

Occupational therapy has inherited from Addams pragmatism the value for practice in the production of scientific knowledge and the understanding of exchanging ideas, which has led it to reconstitute itself in more than one occasion (Morrison, 2021a; Morrison, 2021b). But, in this way some of the initial approaches have been lost, such as the consideration of Addams' social ethics or the aspects of Mead's social psychology. But, with the support from organizations and institutions of people with disabilities and their struggle for social acceptance and inclusion, they have begun to consider apparently hidden values during the boom of biomedical neopositivism in the mid-twentieth century, where the sole purpose of Occupational therapy was to recover the functionality of a “dichotomized” body in mind and matter, that is, increasing the range of joints or decreasing psychiatric symptoms without considering the subjective state of well-being of the person.

The return of pragmatism to the discipline is a path that different occupational therapists have already begun to travel a few years ago, but that has not yet been incorporated into the professional training of some universities, which is expressed in the lack of the concept in the main articles and official publications of the profession.

It does not stop attracting attention, that for more than a century, the pragmatist philosophy remains in force from its initial foundations and how, in these last decades, this philosophy is regaining more strength If compared to previous years. This pragmatism, based on the influences from Mill on utility, from Kant on the regulatory ideas of practical exercise, and from Darwin on evolution and constant change, led the first pragmatists to suggest that ideas are constructed describing ways of referring to the world, which would be true depending on its usefulness and not “the world as it is”. The ideas would correspond to an evolutionary strategy and would have allowed knowledge to develop in different ways over time, which implies that this knowledge is constantly changing. The above ensures that our ideas and conceptions about the world change frequently, which allows us to conclude that ideas are instruments of adaptation to the world.

These approaches are completely consistent with the professional practice of occupational therapists, firstly because of the work we do with people and communities, which implies endorsing, respecting, and often defending different conceptions of the world, involving the therapist as a professional being that redefines themselves in the relationship with clients or patients. And second, because of the value of the practical experience that, as Slagle postulated, it should constitute a professional

⁴ Mainly, because it meant a strategy and a systematization in the way of using the occupation. In the moral treatment, occupations for patients were used according to the needs of the hospital (product marketing); Thus, the work itself was understood as beneficial, so it did not necessarily need a graduation or guidance. With the arts and crafts movement, the perspective of interest on the part of the patients was added. But with occupational therapy, the scientific foundation that validated occupations as a rehabilitative treatment was integrated, focusing on them as a means and not as an end.

exercise based on evidence, which places the pragmatist idea that prioritizes practice by theory, but not in a segmented dichotomy, but from a holistic perspective, in which each one is constantly present, which gives the basis of doing and knowing as professionals.

On the other hand, pragmatist conceptions invite us to create a reality consistent with the maximum utility of the ideas and beliefs of our society. This maxim involves the approaches of Addams, Dewey, Mead, James, Peirce and Slagle and guides the construction of a democratic, pluralistic and inclusive society, implying that occupational therapists are active and permanent agents in social transformation and democratization of our communities.

These ideas are based on the fact that knowledge is flexible, fallible and contingent, so it is impossible for it to be theoretically neutral, without time or independent of a particular historical or political context (Hooper & Wood, 2002). This implies that occupations such as doing science, politics, philosophy, or without going any further, occupational therapy, are spheres of the human – actions – and as such, based on transient, situated and mutable epistemological premises.

Following this idea, Slagle's pragmatist view allows us to reflect on the impossibility of eliminating individual values in professional practice and to consider that our individual and social values are an inherent part of our clinical practice, which rejects neo-positivist ideas. biomedical on the professional / personal dichotomy and on the absence of emotions and feelings in the professional role.

Conclusions.

Although occupational therapists are not trained in philosophy, except in the aspects concerning the reflections on human occupation, they do share some common objectives with the philosophers, as Dewey and Addams could have raised. Philosophers, like occupational therapists, must be critical of the facts and social conflicts that are linked to our fields of action, favoring the democratic function of knowledge while maintaining social transformation as an ideal.

Dewey, Addams, Peirce, Mead, James and Slagle shared the idea of active criticism and thoughtful thinking, which was the basis of their respective careers. Occupational therapists must approach philosophy to obtain answers about our theoretical and practical professional practice. This first generation of occupational therapists, such as Slagle, Tracy, Johnson and Dunton, maintained an active and constant reflection on the profession, an inheritance that from time to time tends to overlap.

I think there is a first step, since pragmatism has been taught, although within the “hidden curriculum” of the discipline. Not with referents or explicit names, but in the holistic and focused on the subjectivity of patients. Of course, this should be strengthened by reviewing the pragmatist bases, which in one way or another, are also the roots of occupational therapy.

On the other hand, I consider it clear that both Tracy and Slagle and their references to pragmatism were not taken into account due to androcentrism. Both referred to pragmatists like Addams, Dewey and James, but were not considered.

Therefore, androcentrism limited the understanding of the theoretical foundations of occupational therapy.

Today, more than 100 years after its foundation, occupational therapy has much to learn, again, from the philosophy of Jane Addams.

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Внесок Джейн Аддамс у розвиток соціотерапії

Анотація. У 1915 році Джейн Аддамс заснувала першу школу соціотерапії в Чикаго, США. У цьому процесі Аддамс надихнула перше покоління соціотерапевтів, особливо Елеонор Кларк Слагл. В цій статті висвітлюється внесок Джейн Аддамс у розвиток соціотерапії через поглиблений бібліографічний огляд періоджерел. Стаття розділена на дві частини. У першій частині досліджуються основи соціотерапії на початку двадцятого століття. У цьому контексті реабілітація жінок у Сполучених Штатах почалася, коли жінки середнього класу почали виконувати низку робіт, які відрізняли їх від їхніх традиційних занять. У результаті було виявлено стосунки та взаємозв'язки між мешканцями школи та першими соціотерапевтами в Чикаго. В другій частині представлені до уваги роздуми про вплив Джейн Аддамс на розвиток і сучасну ідентичність соціотерапії. Джейн Аддамс була взірцем для багатьох перших соціотерапевтів, особливо для Слейла. Вона навчалася в Аддамса своїй наполегливості та лідерським навичкам, центральним аспектам першої школи соціотерапії. Крім того, Аддамс, як філософ прагматизму, поширювала ідеї, які віддають перевагу практиці через теорію. З іншого боку, прагматичні концепції закликають створити реальність, яка відповідає максимальній корисності ідей і вірувань нашого суспільства. Деякі з цих аспектів справедливі в сучасній практиці соціотерапії. Сьогодні, більше ніж через 100 років після заснування, соціотерапія має ще чому навчитися у філософії Джейн Аддамс.

Ключові слова: історія науки; прагматизм; професійна ідентичність; прогресивна епоха; Сполучені Штати Америки

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Biographical materials of mathematicians and natural scientists in “Bulletin of Experimental Physics and Elementary Mathematics” (1886–1917): meaningful and content analysis

***Abstract.** The article presents the results of a study of the features of biographical and prosopographic materials about famous mathematicians and natural scientists, published in one of the most authoritative journals “Bulletin of Experimental Physics and Elementary Mathematics”, which was published in Kyiv and Odesa during 1886–1917. In fact, the journal was an unofficial periodical printed branch of the Mathematical Department of the Novorossiysk Society of Naturalists. The purpose of the study is to conduct a meaningful and content analysis of the texts of the journal articles, which reveal biographies, features of labor activity and participation in scientific research of famous scientists. At the same time, the authors used scientific methods to conduct a meaningful analysis of the subject of research – analysis and synthesis, generalization and systematization. In the process of quantitative content analysis, text quantification, empirical data collection, their generalization, and mathematical and statistical processing were used. As a result of the study of biographical materials of the journal over the period, its authors came to the following*



conclusions. Firstly, the materials of the journal about famous domestic and foreign mathematicians and natural scientists were both biographical and prosopographic in nature. Moreover, the motives for the appearance of such publications, as a rule, were “round” dates from the moment of birth, from the beginning of creative activity, from the moment an important work was released, or from the moment of death (or the fact of death) of the subject of publication. All such articles in the journal are conditionally classified by the authors into brief biographical and prosopographic notes, detailed biographical and prosopographic articles, and obituaries. Secondly, the total volume of biographical and prosopographic materials for the entire period of publication of the journal was 2.88% of the total volume of the journal. At the same time, the journal contained materials about 84 scientists. The largest journal volume by the editors (more than 5 pages for each) was provided by 27 scientists and this amounted to 72.7% of the total volume of biographical material; this group included 9 domestic scientists and 18 foreigners. In total, the editors allotted an average of 4.89 pages for each domestic scientist, and 5.89 pages for each foreign scientist. The largest volume of materials was about physicists (46.42% of the total volume of biographical materials) and mathematicians (35.44%). Thirdly, the results of a meaningful analysis allow us to conclude that the published biographical and prosopographic materials of the journal are of high quality. This was largely facilitated by the careful selection of the authors of articles (or sources of materials), as well as the special requirements of the editors for documenting sources of materials in paginated links. Fourthly, the “inattention” of the editorial staff of the journal to a number of “round dates” of famous domestic and foreign mathematicians and physicists, as well as the uneven volumes allocated by the journal for biographies, indicate the absence of a clear editorial policy of the journal in the issue of allocating printed volumes for systematic biographical statements and research.

Keywords: *biography; prosopography; meaningful analysis; content analysis; mathematicians; natural scientists*

Introduction.

The article is devoted to the history of the development of popular scientific and scientific-methodical journals in Physics and Mathematics, which were published and distributed on the territory of modern Ukraine (at that time – part of the territory of the then Russian Empire) at the end of the 19th – beginning of the 20th century. One of the most authoritative journals among Mathematics teachers, high school students and amateurs of Mathematics and Physics of that period was the journal “Bulletin of Experimental Physics and Elementary Mathematics”, published in Kyiv and Odessa during 1886–1917. A feature of this journal was that, in addition to articles on Mathematics and Physics, the editors paid special attention to the section of problems, which in some issues occupied more than half of the volume of the journal. An important place throughout the entire period of publication of the journal was occupied by biographies – articles about outstanding scientists representing the natural sciences and mathematical branches of knowledge. The study and analysis of biographical

heritage on the example of this journal is of great interest from the point of view of assessing the activities of scientists of the late XIX – early XX century by their contemporaries.

Literature review. The development and role of the journal “Bulletin of Experimental Physics and Elementary Mathematics” in the formation of educational thought in the period of education reforms of the late 19th – early 20th centuries was studied by various scientists. V. S. Savchuk (1994) explored this topic in the context of the development of the society of naturalists in the south of the Russian Empire, D. V. Okhremenko (1973) – as a factor in improving the general educational and pedagogical culture of mathematics teachers of the empire of that time, V. D. Pavlidis (2013; 2016) and N. A. Ternovaya (2012) – as an integral part of the reform of mathematical education in the Russian Empire at the end of the 19th – beginning of the 20th century. A rather original and thorough general description of the contents of the journal throughout the entire period of its publication is presented in the study by S. A. Dahiya (1956). In a scientific study by D. M. Zhivotivska (2015) presents an analysis of the information and journalistic activities of the mathematical department of the Novorossiysk Society of Naturalists, which was directly involved in the publication of the journal. However, it is precisely the articles of a biographical and prosopographic nature, which reveal the features of the life and work of famous scientists, that have not become the subject of research.

Therefore, the purpose of the article is to conduct a meaningful and content analysis of the articles of the journal “Bulletin of Experimental Physics and Elementary Mathematics”, which reveals the features of life and details of participation in scientific research of famous mathematicians and natural scientists.

Research methods.

During the study, scientific methods were used – analysis and synthesis, generalization and systematization – to conduct a meaningful analysis of the subject of research. In the process of quantitative content analysis, text quantification, collection of empirical data, their generalization and mathematical and statistical processing were used (Atteslander, 2003; Früh, 2003). At the stage of text quantification, journal issues were used as content units, which were combined by year of publication, and as a unit of account – the number of pages in a particular issue, which revealed the content of the biography or prosopography of the scientist (parts of the page volume were determined from the ratio of the occupied area on the page).

Results and discussion.

The journal “*Bulletin of Experimental Physics and Elementary Mathematics*”, published in Russian during 1886–1917 in Ukraine (first in Kyiv, and then in Odessa), together with its previous version – “*Journal of Elementary Mathematics*” (1884–1886, Kyiv) – is considered the best edition of the popular mathematical and natural science periodicals of the Russian Empire of the late XIX – early XX century. The founder and first editor of the Journal of Elementary Mathematics was Professor of

Kyiv University V. P. Ermakov. Since 1886, the editing of the journal was transferred to E. K. Shpachinskyi, who had previously actively participated in the editorial work of this publication. At the same time, the journal changed its name to “Bulletin of Experimental Physics and Elementary Mathematics” (hereinafter – “BEPHEM”). At the request of E. K. Shpachinskyi V. P. Ermakov remained the ideological leader of its mathematical part. In 1891, the editors of the journal “BEPHEM” moved to Odessa, and the editing of the journal from 1898 (after a short stay as chief editor of Professor V. A. Zimmerman) and until the termination of its publication was transferred to Privatdozent V. F. Kagan and subsequently contacts the mathematical department of the Novorossiysk Society of Naturalists and the teachers of the Novorossiysk (Odessa) University. The publisher of the journal during 1897–1917 (from No. 259) was V. A. Gernet. Historians conditionally call the period 1886–1897 the first period of the existence of the journal and, accordingly, 1898–1917 – the second one (Dahiya, 1956, p. 546). During the entire period of publication of the journal “BEPHEM”, scientists from Kyiv, Kharkiv and Odessa were active members of the journal: S. N. Bernstein, E. L. Bunitsky, V. F. Kagan, D. M. Sintsov, I. Yu. Timchenko, I. V. Sleshinsky, S. I. Shatunovskyi, V. A. Zimmerman and others (Dahiya, 1956). In fact, “BEPHEM” was an unofficial periodical printed organ of the mathematical department of the Novorossiysk Society of Naturalists, in which physicists and mathematicians from the territory of present-day Ukraine, as well as from all over the Russian Empire, were involved in cooperation (Dahiya, 1956).

During 1886–1917, the editors published 674 issues of the BEPHEM magazine in 627 books with a total volume of 16,066 pages. Materials revealing the details of the biography and work of famous mathematicians and natural scientists accounted for 2.88% of the total volume of the journal for all the years of its publication. In the content of the journal articles, there were both biographical materials (in the form of a scientific biography) and prosopographic materials, when the personalities of scientists were studied in the totality of their personal qualities, characteristics of their creative path and relationships with others, taking into account the environment and time. Without aiming to classify journal articles into biographical and prosopographic (due to the impossibility and unnecessariness of this action), we will conduct a meaningful analysis and content analysis of this part of the journal material.

The appearance of journal articles of a biographical and prosopographic nature, as a rule, was motivated by a special date in the life of the subject of publication. Among such motifs there were anniversaries of scientists, as well as on the days of memory round dates from the moment of their birth, or from the beginning of their creative activity, or from the moment of the discovery, or from the moment of the release of an important work. In addition to the mentioned facts, the anniversaries (as a rule, multiples of 100) from the day of the death of the scientist or the very fact of death were also motives. All such articles in the journal can be classified as follows: a) brief biographical and prosopographic notes; b) detailed biographical and prosopographic articles; c) obituaries.

Let us preliminarily note that naturally the amount of material presented in the journal depended on the editorial staff’s ideas about the degree of greatness of a

scientist. We conducted a meaningful analysis of the articles that have the largest volume (Fig. 1).

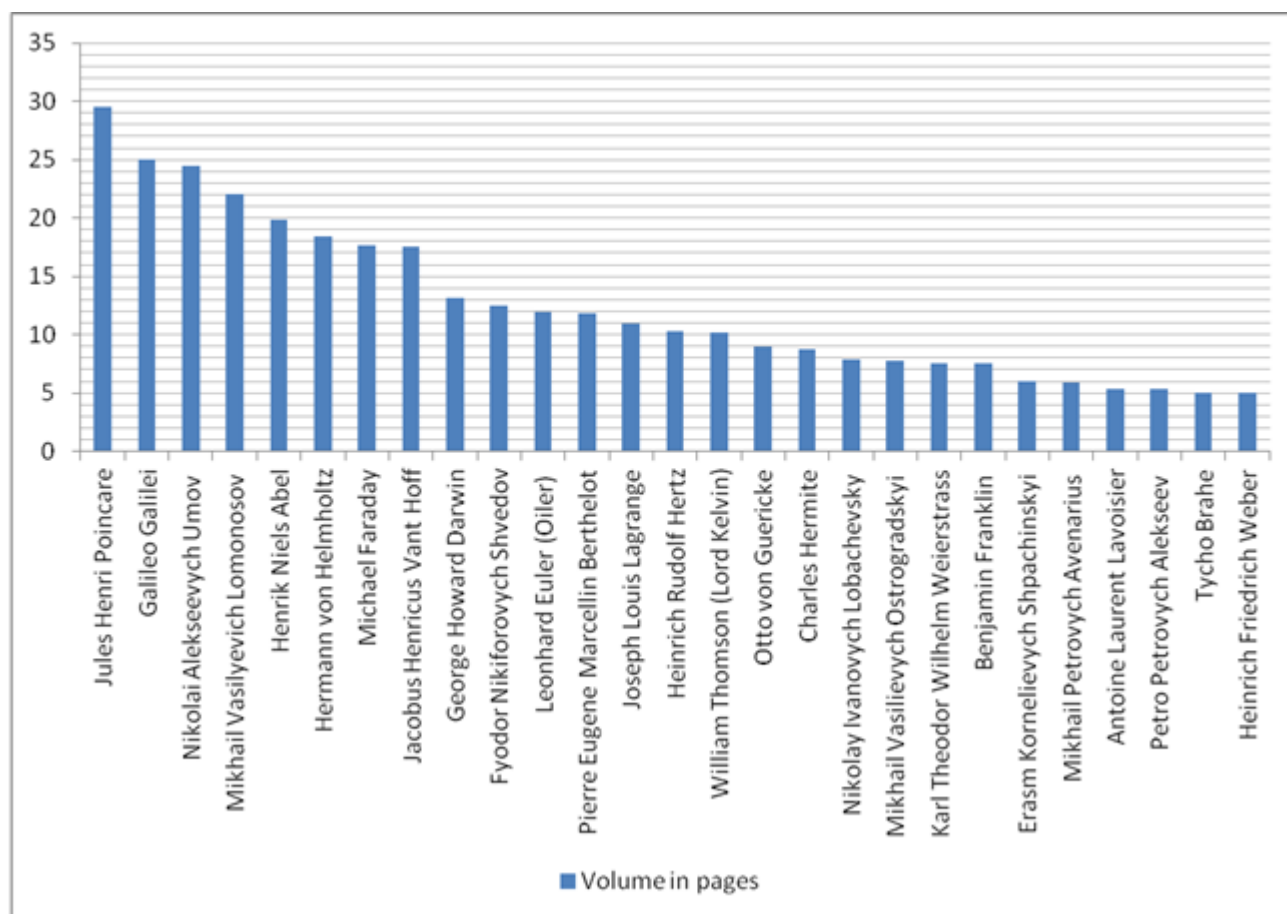


Figure 1. Scientists whose biographical materials had the largest amount of text.

The editors of the journal paid special attention to the famous mathematician *Jules Henri Poincare*, who died at the age of 58 in 1912. The entire 566 issue of the journal was devoted to this scientist, in which excerpts were provided from the speech of F. Masson (Director of the French Academy), from the report of G. Rados to the Hungarian Academy of Sciences, from the speech of G. H. Darwin about the great scientist at a meeting of the Royal Astronomical Society in London, as well as the work of H. Poincare himself “The relationship between matter and ether” (Poincare, 1912). President of the Royal Astronomical Society G. H. Darwin in his speech (Extract from the address, 1912) described three areas of H. Poincare’s research in astronomy: research on the dynamic theory of ebbs and flows, on the equilibrium figures of liquid rotating masses, and research on the theory of the motion of planets and their satellites. G. Rados in his report (Extraction from the report, 1912) noted the mathematical achievements of “the undeniably first and most powerful modern researcher in the field of Mathematics and Mathematical Physics” (Extract from the report, 1912, p. 57): development of the theory of automorphic and analytic functions, creation qualitative theory of differential equations and the theory of Topology. F. Masson’s speech (Anonymous, 1912) is a vivid example of a parallel presentation of the biography of H. Poincare and prosopographic materials. The author outlined in detail the features of

the scientist's life path and characterized the internal and external conditions. A special place in the issue is occupied by the article by H. Poincare (1912), which fully reveals him as a universal scientist and professional philosopher. By the way, H. Poincare was one of the active authors of the BEPhEM journal – from 1893 to 1912, the journal reprinted and translated into Russian 12 of his articles on various problems of Mathematics, Mechanics, Physics, Astronomy and Philosophy.

In 1892, the 250th anniversary of the death of *Galileo Galilei*, “the titan of thought, whom Mechanics, Astronomy and Physics can fairly call their father and founder” (Pergament, 1892, p. 177), was celebrated. In this regard, a large material of the Odesa lawyer and public figure O. Ya. Pergament (Krasnova & Drozdovskij, 2015) about a scientist – Italian physicist, mechanic, astronomer, philosopher, mathematician (Pergament, 1892). Using a large number of Italian, German, French and Russian sources, the author described the biography of the scientist in great detail, and also studied the personality of Galileo in the totality of his personal characteristics and qualities, details and motives of his creative path and relationships with the outside world and society in the context of conditions in Italy at the end of the 16th century and the beginning of the seventeenth century. The author, summing up the story, concludes that Galileo's scientific activity was successful in all branches of contemporary natural science, and regrets that not all of the scientist's works were published – most of the works were lost and destroyed by the Inquisition (Pergament, 1892, p. 253). However, an analysis of the scientist's letters gives reason to judge the exceptional genius of his ideas, which were confirmed only two centuries after his death (Pergament, 1892, p. 253).

One of the largest materials in terms of volume was the obituary and the text of the speech of V. F. Kagan at a meeting of the Novorossiysk Society of Naturalists in connection with the death of the theoretical physicist, philosopher *Nikolai Alekseevych Umov* (Kagan, 1915). N. A. Umov from 1871 to 1893 was an assistant professor, then an extraordinary and ordinary professor in the department of Physics at Novorossiysk University, and from 1893 he went to Moscow University, where he became its honored professor. Prosopographic material of V. F. Kagan is dedicated specifically to the Odesa period of the life and work of the scientist. The author describes in detail the tolerance of N. A. Umov as a scientist and a person, the formation of his attitude to Physics and Mathematics, passion for a mechanistic worldview, personal experiences of failures in choosing students. A particular problem for the scientist was the difficult perception of new ideas in Physics with the advent of research on quantum mechanics: “The extremely rapidly unfolding picture of natural science revealed such a complexity of living nature that ... reducing it to elementary physical and chemical processes became like a utopia” (Kagan, 1915, p. 86). These lines could be the epigraph of the named prosopographic material.

A large volume of material was devoted to *Mikhail Vasilyevich Lomonosov*, the first Russian physicist and chemist (as the author of the article, the historian of chemistry B. N. Menshutkin, positions it) (Menshutkin, 1905). The article is an extensive prosopographic material about Lomonosov's scientific convictions, about the conditions and environment in which the scientist's activities were carried out. The

author explains the scientist's uncertainty among his contemporaries during his lifetime by the following factors: a) many of the scientist's works were unfinished manuscripts; b) contemporaries did not understand his scientific conclusions; c) his literary activity was better known to his contemporaries (Menshutkin, 1905, p. 67).

In honor of the 100th anniversary of the birth of the famous Norwegian mathematician *Henrik Niels Abel*, the journal published the text of the speech of the leader of the world-famous school of Logics and Mathematics, I. V. Sleshinsky (Rikun, 2015) at a meeting of the Society of Naturalists at the Novorossiysk University (Sleshinsky, 1903). The speech contains a brief biography of the scientist and is an example of professionally structured prosopographic materials that reveal the inner world of a mathematician and the features of external conditions in the context of making the greatest discoveries in 3 areas: in the theory of algebraic equations, in the theory of elliptic functions and in the general theory of integrals of elliptic functions (Sleshinsky, 1903, p. 195).

At the end of 1891, at the solemn meeting of the Novorossiysk Society of Naturalists, dedicated to the 70th anniversary and the 50th anniversary of the creative activity of the German physicist *Hermann Ludwig Ferdinand von Helmholtz*, assistant professor of Novorossiysk University G. G. De-Metz (physicist, rector of Kyiv University (1917) and Kyiv Polytechnic Institute (1919)) presented a report (De-Metz, 1891), which outlined the biography of the scientist and a lengthy "outline of the scientific activity of the culprit ... triumph" (De-Metz, 1891, p. 161). H. von Helmholtz brilliantly conducted scientific research in various fields – in Physics, Physiology, Psychology, Aesthetics, Painting, Music, was a man of exceptional abilities and versatile education, "fair to others, full of the noblest feelings, strict to himself" (De-Metz, 1891, p. 191). The scientist immortalized his name in the history of science with the lion's share of substantiating the truth of the physical law of conservation of energy.

Another article by O. Ya. Pergament was dedicated to the 100th anniversary of the birth of the British physicist *Michael Faraday* (Pergament, 1891), in which the author uses the biographical book of Faraday's student Tyndall as a source. And in this case (as well as in the article about Galileo), the author presented the material in the form of a qualitative scientific biography with elements of prosopography, noted Faraday's merits "in the field of physics in general and in the science of electricity in particular" (Pergament, 1891, p. 71). Among the scientific merits of the scientist are the discovery of magneto-electric induction, the study of chemical phenomena of electric current, the discovery of magnetization of light and diamagnetism, research on the liquefaction of gases. The author concludes: "Every minute of Faraday's life is an epoch for science" (Pergament, 1891, p. 97).

Italian physicist-chemist, professor at the University of Padua, Giuseppe Bruno, published extensive material about the Dutch physicist and chemist, winner of the first Nobel Prize in Chemistry in 1901, *Jacobus Henricus Vant Hoff* (Bruno, 1912) (after the scientist's death). The author focuses attention on Vant Hoff's scientific research in the following areas: stereochemistry, the science of chemical equilibria, the theory of dilute solutions, and research on salt deposits in Stassfurt. The article is a scientific biography of a scientist with a clear selection of the periods of his scientific activity.

The author of the article, emphasizing Vant Hoff's scientific merits, concludes that "of the four major areas developed by him, any one would be enough to bring him the glory of a great chemist" (Bruno, 1912, p. 167).

The article about *George Howard Darwin* – professor of astronomy at Cambridge University, son of Charles Darwin – was written in the form of a detailed analysis of his scientific creativity (Henckel, 1911). G. Darwin is an English astronomer and mathematician, who gained world fame as a scientist who created the tidal theory of evolution, studied tides, low tides and periodic orbits, as well as forms of equilibrium and stability of liquids. The article about the scientist is an analysis of the content and features of the creation of the components of the entire scientific collection written by G. Darwin, published by the Cambridge printing house.

Report of the private associate professor of the Department of Physics and Physical Geography of the Novorossiysk University I. Ya. Tochydlovskiy, which was read at the meeting of the Novorossiysk Society of Naturalists, was dedicated to the memory of the deceased *Fyodor Nikiforovich Shvedov*, a physicist, rector of the university (Tochydlovskiy, 1906). The report contained both the scientist's biography and prosopographic materials about the professor's inner world and external conditions and relationships that influenced his activity and creativity. The author of the report noted that as a scientist F.N. Shvedov established an analogy between electrical and light phenomena, investigated the causes of the formation of various forms of comets and the peculiarities of the conversion of electricity into heat, invented an aiming rangefinder for coastal defense and naval attack.

On the 200th anniversary of the birth of the famous mathematician, native of Basel, director of the Berlin Royal Academy of Sciences, member of the Academy of Sciences in St. Petersburg, member of Paris, London and many other scientific societies, *Leonhard Euler*, the journal publishes a biographical sketch compiled from primary sources and family papers of Schultz-Euler (Schultz-Euler, 1907). L. Euler was the author of more than 800 works on mathematical analysis, differential Geometry, number theory, approximate calculations, celestial mechanics, mathematical physics, optics, ballistics, shipbuilding, music theory. The author of the essay summarizes: "Along with Galileo, Descartes, Leibniz and Newton, Euler's name will die only together with science itself" (Schultz-Euler, 1907, p. 206).

In honor of the 50th anniversary of the beginning of the scientific activity of the French chemist *Pierre Eugene Marcellin Berthelot*, the journal published reports by professors P. G. Melikov (Melikov, 1901) and S. M. Tanatar (Tanatar, 1901) at a meeting of the Novorossiysk Society of Naturalists. In the reports, the authors presented an analysis of the jubilee's scientific achievements in the field of kinetic reactions, organic synthesis, thermochemistry and the history of science, and also noted his activity as a public figure.

The article by W. Ahrens (Ahrens, 1913), dedicated to the 100th anniversary of the death of the French mathematician, astronomer and mechanic *Joseph Louis Lagrange*, is a classic prosopographic material about the work of a scientist, about the factors and personalities influencing his results, about the inner scientific world of the researcher. J. L. Lagrange was the author of variational calculation and the

mathematization of Mechanics, he made a huge contribution to the theory of Differential Equations, Theory of Numbers, Theory of Probability, and Algebra.

In 1906, on the eve of the 50th anniversary of the birth of *Heinrich Rudolf Hertz*, the posthumous unpublished memoir of H. Helmholtz “The Life and Labors of Heinrich Hertz” (Helmholtz, 1906) was published in the magazine (H. Helmholtz was the teacher of H. Hertz, who died in 1894). This material is a professionally made prosopography by a famous physicist of the experimental confirmation by H. Hertz of J. Maxwell’s electromagnetic theory of the world.

In 1907, the editors of the magazine published an obituary on the death of the British physicist, mechanic and engineer *William Thomson (Lord Kelvin)* (Editorial, 1907). The obituary presents a brief analysis of the scientist’s engineering and scientific achievements: the calculation of the transatlantic cable, the theory of the absolute temperature scale, the theory of energy dissipation, research on the mechanical energy of the solar system and the theory of vortex motion.

The editorial article of 1886 for the 200th anniversary of the death of the German physicist and philosopher *Otto von Guericke* (Editorial, 1896) is the first detailed prosopographic material of the magazine. Being the mayor of Magdeburg for 32 years, the scientist managed to engage in inventive activity – he studied the properties of vacuum (Magdeburg hemispheres) and air (pressure, elasticity, sound conductivity, combustion support), invented a water barometer and an electrostatic generator.

Four relatively large articles were dedicated to mathematicians. In 1893, in honor of the 100th anniversary of the birth of the Russian geometer *Nikolay Ivanovich Lobachevsky* (inventor of non-Euclidean geometry), two articles were published in the journal (Vasiliev, Suvorov, 1893; Bondarenko, 1893), in which biographical information is disclosed about the scientist. His scientific achievements are also analyzed here (it should be added that during 1893–1898, in 20 issues of the magazine, V. F. Kagan’s book “Essay on Lobachevsky’s Geometric System” was published; it was the only fully printed book during the entire period of the publication’s existence). In 1897, in connection with the death of the famous German mathematician (the “father” of mathematical analysis, developer of the theory of special functions, researcher of variational calculations, differential geometry and linear algebra) *Karl Theodor Wilhelm Weierstrass* in “*Bulletin...*” I. V. Sleshinsky’s obituary was published (Sleshinsky, 1897), and P.M. Pokrovsky – a note about the scientist (Pokrovsky, 1897). Also, on the occasion of the death of the French mathematician, H. Poincaré’s teacher, *Charles Hermite* (the author of studies of orthogonal polynomials, the theory of quadratic forms, elliptic functions, the transcendence of the number e) in 1901, the journal published an obituary (Editorial, 1901a) and a note about the scientist (Timchenko, 1901). All these articles contain professionally developed biographical and prosopographical material. And to commemorate the 100th anniversary of the birth of the Ukrainian mathematician, mechanic and physicist *Mikhail Vasilievych Ostrogradskyi*, in 1901, the editor’s article “Memories of M. V. Ostrogradskyi” (Editorial, 1901b), and in 1903, an article by the professor of Kharkiv University D. M. Sintsov “To celebrate the centenary of the birthday of M. V. Ostrogradskyi” (Sintsov, 1903). Both materials contain a description of the features of the scientist’s

life path, an analysis of his scientific research in the field of applied aspects of mathematical analysis, theory of probability, mechanics, and the statement of the scientist's important scientific results (the Ostrogradskyi method for integrating rational functions and the Ostrogradskyi formula for transforming a volume integral into a surface integral). The articles also contain a description of the conditions of the scientist's creativity and the features of celebrating the anniversary of M. V. Ostrogradskyi in Poltava.

Speech by E. K. Shpachinskyi, which he delivered at a meeting of the Kyiv Physical and Mathematical Society, was dedicated to the 100th anniversary of the death of *Benjamin Franklin* and was published in the 101st issue of the journal (Shpachinskyi, 1890). The material has the form of a scientific biography of an American public figure and scientist and contains a description of his main scientific discoveries (the study of the nature of electricity, the invention of the Pennsylvania fireplace and the electric motor, the explanation of the working principle of the Leyden bank, the improvement of the harmonica). The author concludes the report as follows: "No matter how many hundred years have passed since the day of his death, the name of Benjamin Franklin will always occupy one of the most honored places in the history of civilization".

Second material by E. K. Shpachinskyi in the form of a scientific biography was published on the occasion of the death of the professor of Experimental Physics of Kyiv University *Mikhail Petrovych Avenarius* (Shpachinskyi, 1895). The creator of the first experimental Physics laboratory in Ukraine, a researcher of the liquid state and vapor under changes in temperature and pressure, as well as the dependence of the thermoelectromotive force on the temperature of joints, the author of the formula for this dependence, one of the most famous professors of the Kyiv School of Physics.

Another voluminous obituary that is about the death of Kyiv University professor *Peter Petrovych Alekseev* was published in the early period of the magazine's existence (*Volodkevych*, 1891). The article contained elements of biography and prosopography. The scientist-chemist was known for the establishment of a new chemical laboratory at the university's chemical faculty and for the study of nitrogen-containing organic compounds.

One of the magazine's major articles was dedicated to the death of *Erasm Korneliievych Shpachynskyi* himself (Editorial Office, 1913), the founder and editor of the BEPhEM magazine until 1898. In the biographical article, the features of the editor's activities at different stages of the establishment and development of the journal, to which E. K. Shpachinskyi devoted more than 10 years of his life.

The last obituary from among those that occupied 5 or more magazine pages was published on the occasion of the death of the German mathematician, professor of the University of Strasbourg *Heinrich Friedrich Weber* (Shatunovskyi, 1913). In the prosopographic material, Weber is shown as an outstanding student of Riemann and Kronecker, a skillful mentor of university students, the author of mathematical bestsellers (the three-volume Algebra, the two-volume Differential Equations of Theoretical Physics, and the Encyclopedia of Elementary Mathematics) and the editor of the complete collection of Riemann's works.

The editor's prosopographic article "Role of Lavoisier in the history of Chemistry" (Editorial, 1915) is devoted to defining the merits of *Antoine Laurent Lavoisier* as the founder of modern chemistry. This is one of the few magazine articles that was not timed to a certain date of the scientist. The second purpose of this material is to conduct an analysis of sources in the history of Chemistry, which determined the scientist's contribution in different ways. The article reads: "Lavoisier quite rightly used, continued and borrowed the works and thoughts of his predecessors, because he really was in the field of these works and ideas, and it was in this area, thanks to the inclinations of his mind and the conditions of the environment, that he could express his fruitfulness... If other scientists released new currents, then Lavoisier completed an entire era of works with his truly great synthesis" (Editorial, 1915, p. 230).

Another article of a prosopographic nature, the appearance of which was not connected with a round date in the scientist's life, was dedicated to the American inventor and entrepreneur *Thomas Alva Edison* (I.R., 1891). The article had the character of a sharply critical and condemning enthusiasm for Edison's inventions, calling the entire company of support for the American invention "Edisonomania".

In 1901, to the 300th anniversary of the memory of the Danish astronomer, astrologer and alchemist *Tycho Brahe* – "the immortal founder of modern practical astronomy, who was the first to organize and bring astronomical observations to such a degree of accuracy that with their help it turned out to be possible to prove the validity of the Copernican world system" – materials of a prosopographic character are published in the journal (*Srebryanskyi*, 1901).

Among the other materials of a smaller volume of prosopographic nature, we note the appearance in the journal of obituaries on the occasion of the death of outstanding scientists – the creator of the theory of the chemical structure of organic substances *Alexander Mikhailovich Butlerov* (Alekseev, 1886), the researcher of number theory and theory of probability of *Pafnutiy Lvovich Chebyshev* (Vasiliev, 1894), the founder of the theory of real numbers, *Julius Wilhelm Richard Dedekind* (Editorial, 1916a), the English philosopher and sociologist *Herbert Spencer* (Editorial, 1904), the French physicists, the discoverers of radioactivity, *Antoine Henri Becquerel* (*Letnik*, 1908) and *Pierre Curie* (Adamovych, 1906), German researchers of mathematical Physics *Gustav Robert Kirchhoff* (Avenarius, 1887) and theoretical thermodynamics *Rudolph Julius Emanuel Clausius* (Avenarius, 1888), the author of the periodic law of chemical elements *Dmitry Ivanovich Mendeleev* (Editorial, 1906) and a researcher of mathematical analysis and Differential Geometry *Jean Gaston Darboux* (Editorial, 1916b).

However, more than two dozen biographical materials of the magazine are devoted to lesser-known domestic creative personalities who were employees of the magazine, teachers, textbook authors, university professors, and education officials.

Moving on to the results of the content analysis. So, biographical materials revealing the details of the biographies and works of famous mathematicians and natural scientists were published in 120 issues of the magazine, while information was provided to readers about 84 subjects of biographies with a total volume of 462.7 pages. The materials that aroused the interest of the editors (which was expressed in their

volume) and were analyzed in detail by us above (Fig. 1), comprised information about 27 subjects and had a total volume of 336.3 pages (72.7% of the total biographical volume material). This group included 9 domestic scientists (volume of materials – 103.8 pages) and 18 foreigners (volume of materials – 232.5 pages, which was 69.1% of the total number of materials in this group of articles).

The general distribution of materials by year of publication of the journal is shown in fig. 2.

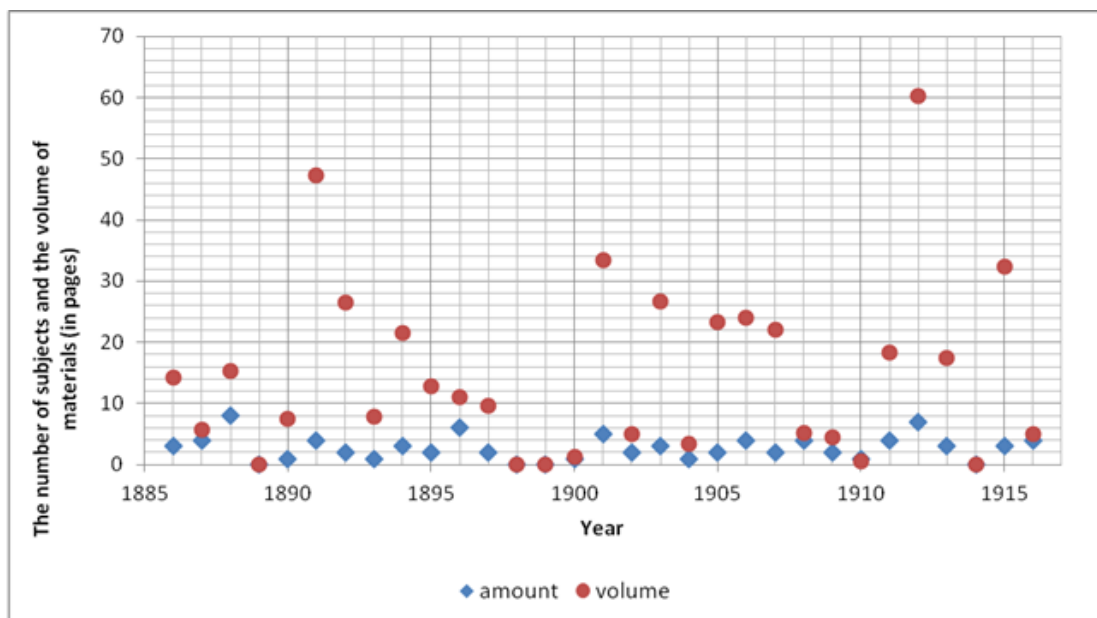


Figure 2. General distribution of biographical materials by years of magazine publication.

Moreover, the number of subjects of biographical materials with distribution by year and differentiation into domestic scientists and foreigners is shown in Figure 3.

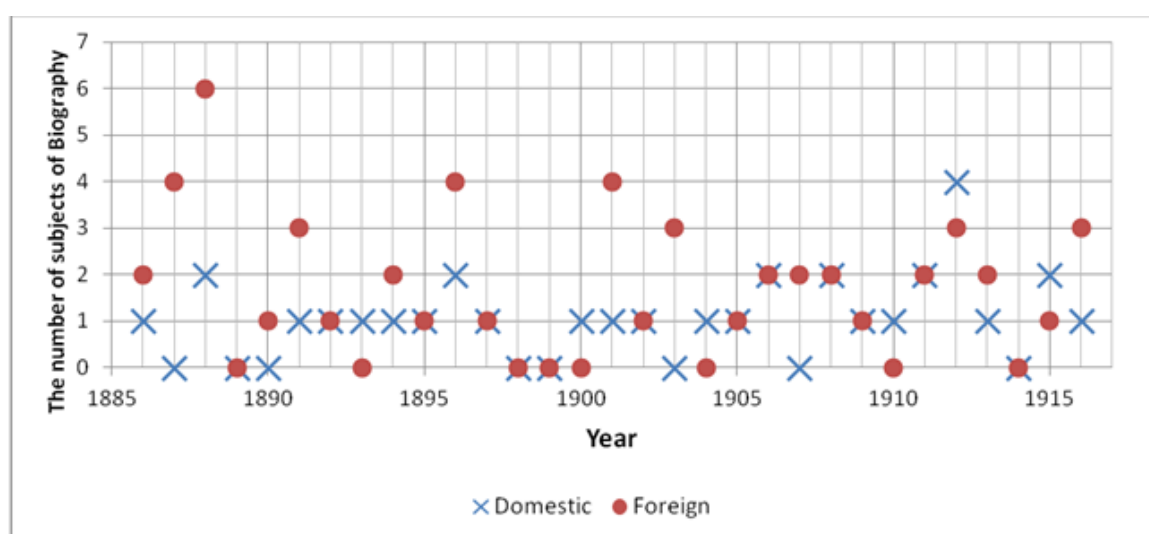


Figure 3. Number of subjects (domestic and foreign) of biographical materials with distribution by year.

And the same distribution by years and subjects, but by the volume of published materials of biographical content – in Figure 4; it can be noted that the editors allocated

an average of 4.89 pages for each domestic scientist, and 5.89 pages for each foreign scientist.

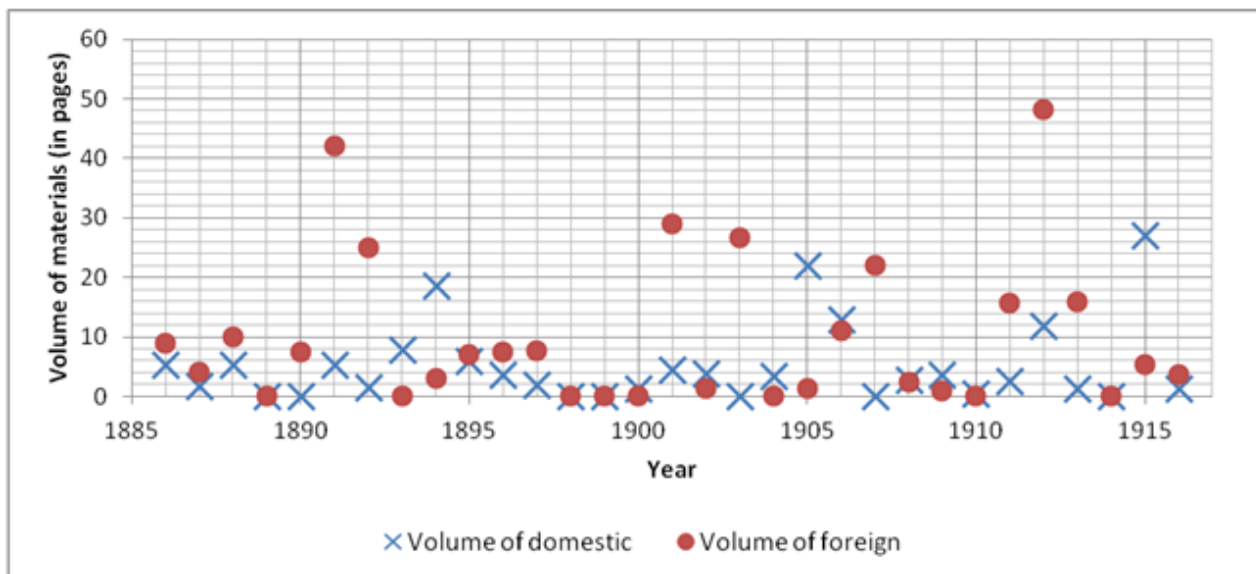


Figure 4. Volume of biographical materials about domestic and foreign scientists with distribution by year.

The percentage distribution of published biographical materials by specialty of scientists, depending on the number of subjects of publications and their volume, is shown in Figure 5.

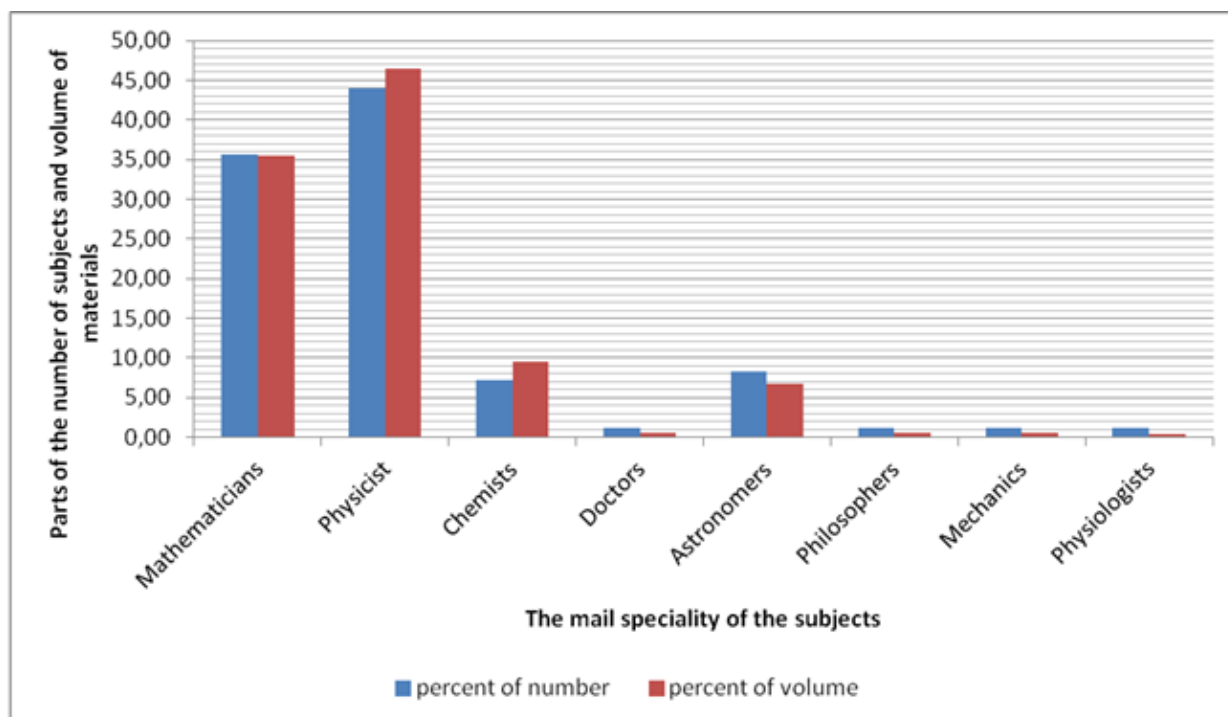


Figure 5. Percentage distribution of the number of subjects of publications and their volume by the specialties of scientists.

In addition, we separately analyzed the indicators of domestic and foreign mathematicians and physicists. Indicators by the number of subjects and by the volume

of materials with the distribution by specified groups of scientists are shown in Figure 6. Note that the largest average volume of materials that the journal published per scientist was devoted to foreign mathematicians (6.5 pages per subject), and the smallest is for domestic mathematicians (4.56 pages). However, among scientists of all specialties, the journal allocated the largest volume of materials per one biographical subject to foreign chemists (11.57 pages).

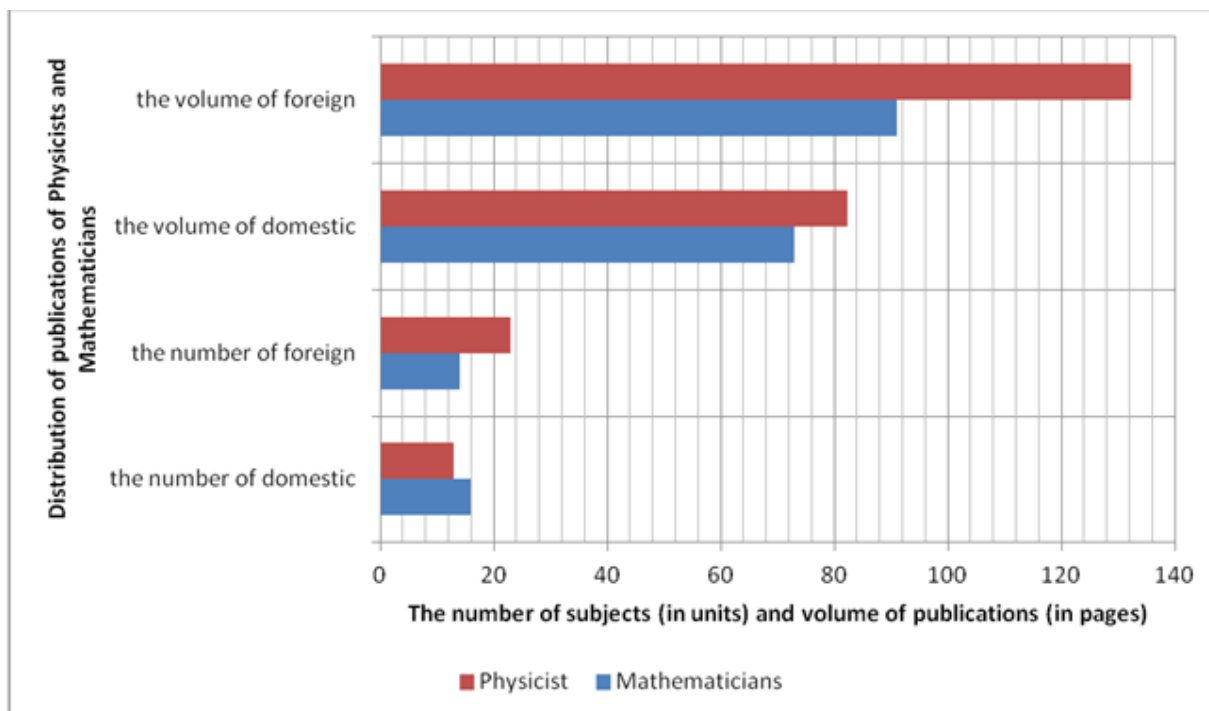


Figure 6. Distribution of domestic and foreign mathematicians and physicists by the number of subjects of biographical materials and their volume.

Discussion.

Several positions that arose in the process of research will be commented. The first thing that catches the attention is the very high quality of the published materials. And here, the selection of the authors (in some cases, the sources) of the publications by the editors of the magazine played a role. And such a “tone” of high-quality presentation of materials was set by one of the first editorial “prefaces” of the journal about *Otto von Guericke* (Editorial, 1896). In this article, the conditions and results of the scientist’s creative activity were analyzed with particular care, and the references make it clear what volume of literature (including foreign literature) was used. Other editorial biographical materials can also be characterized in the context of quality (Editorial, 1907; Editorial, 1901a; Editorial, 1901b; Editorial, 1913; Editorial, 1915). When describing the life and work of *Jules Henri Poincare*, the second version of the submission of materials was used – a recording of the speech of the manager of the Academy of Sciences of France and Hungary and the professor of the Royal Astronomical Society (Anonymous, 1912; Extract from the report, 1912; Extract from the address, 1912). A similar algorithm was used in publications, for example, (Sleshinsky, 1903; Sleshinsky, 1897), which were a recording of the speeches of famous domestic scientists at a meeting of the Society of Naturalists at Novorossiysk

University. In addition to the mentioned options for organizing publications, the editors used articles by well-known public figures (Pergament, 1891; Pergament, 1892), well-known domestic (Kagan, 1915) and foreign scientists (Bruno, 1912; Helmholtz, 1906), as well as relatives of scientists (Schultz-Euler, 1907). Some articles were personally written by the editor of the magazine E.K. Shpachinskyi (Shpachinskyi, 1890; Shpachinskyi, 1895). In addition, given the clearly non-historical orientation of the magazine, the quality of the texts is ensured by the practically exemplary documentation of the sources of materials in page references.

The second moment. We noted above that the amount of biographical material presented in the magazine depended on the opinion of the editorial staff or the author of the publication about the “degree of greatness” of the scientist. In general, one can largely agree with the views of the editors. Nevertheless, it is difficult to explain the “minimalism” of the editors in determining the volume of material about *V. E. Weber* (inventor of the telegraph), *U. J. Verrier* (discoverer of Neptune), *I. Newton*, *D. I. Mendeleev*. And if the texts provided about the first two researchers contain certain information about the main achievements of scientists, then a small material related to the 200th anniversary of the publication of his “Principia” is dedicated to *I. Newton*, although in 1893 the entire scientific world celebrated the 250th anniversary of his birth scientist, but there was not a word about it in the magazine. The same “fate” befell many world-renowned mathematicians and physicists, and not only foreign ones (*C. F. Gauss* in 1905, *G. W. Leibniz* in 1896 and 1916, *R. Descartes* in 1896 and 1900, *P. Fermat* in 1907 and 1915, *B. Pascal* in 1912, *G. S. Ohm* in 1889 and 1904, and many others), but also domestic (*S. Kovalevskaya* in 1891, *L.P. Magnytskyi* in 1889). These facts, as well as the absence of mentions of many domestic and foreign scientific celebrities in the years of their “round” dates, most likely indicate the absence of a magazine policy in the matter of allocating printed volumes for systematic biographical statements and research.

Several articles were not timed to the “round dates” of scientists (Editorial, 1915; I.R., 1891). Such articles also include the article about *M. V. Lomonosov* (Menshutkin, 1905), which raised many questions for us. In addition to the features of this material listed above, it notes Lomonosov’s “special” friendship with the Swiss mathematician *L. Euler* (Menshutkin, 1905, p. 27), his authorship in the formulation of the law of conservation of energy (Menshutkin, 1905, p. 64) and a claim to the scientific community due to the assignment of primacy in the formulation of the law by *A. L. Lavoisier* (Menshutkin, 1905, p. 65). But at the same time, neither in the large magazine material about *L. Euler* (Schultz-Euler, 1907), nor in the editorial article on the scientific merits of *A. L. Lavoisier* (Editorial, 1915) does not have a single mention of Lomonosov. Moreover, neither in 1911 (the 200th anniversary of the scientist’s birth) nor in 1915 (the 150th anniversary of his death) in the materials of the BEPhEM magazine was there any information about the “first Russian physicist and chemist” (Menshutkin, 1905, p. 8). And in Russia’s first original work on the history of Chemistry, “Essay on the Development of Chemical Views” (1888), *N. A. Menshutkin* (father of the author of the publication) (Menshutkin, 1905) mention of Lomonosov is

of a formal nature. We think that these questions are a motive for a more detailed study of this problem.

The maximum number of biographical materials in the magazine during each year of its publication never exceeded 8 (Fig. 2). But at the same time, the annual volumes of materials were very different – from 0 to more than 60 magazine pages. Let's consider in more detail – what materials caused such an increase in volumes. The maximum of 1891 was associated with two large materials about *Michael Faraday* (17.6 pages) and *Hermann von Helmholtz* (18.4 pages), which were published in connection with the jubilee dates of the scientists. The maximum of 1901 is associated with materials about the French chemist *Pierre Eugene Marcellin Berthelot* (11.8 pages, jubilee of scientific activity), 1915 is about the professor of Novorossiysk University *Nikolai Alekseevych Umov* (24.5 pages, obituary). The record is the maximum of 1912, when 29.5 pages of posthumous materials about *Jules Henri Poincare* (an entire issue of the magazine was devoted to the famous mathematician) and 17.5 pages about *Jacobus Henricus Vant Hoff* were published. We will also note the maxima of 1892 (*Galileo Galilei*, 25 pages), 1894 (*P. L. Chebyshev*, 18.6 pages), 1903 (*Henrik Niels Abel*, 19.9 pages), 1905 (*Lomonosov M. V.*, 22 pages), 1906 (*F. N. Shvedov*, 12.5 pages; *Heinrich Rudolf Hertz*, 10.3 pages), 1907 (*Leonhard Euler*, 11.9 pages; *William Thomson*, 10.2 p.). In 1889, 1898 and 1914 the journal of biographical materials was not printed (it was not published in 1899). These facts also indicate the absence of a clear editorial policy in the systematic use of biography.

Conclusions.

Researching the content and carrying out a content analysis of the biographical materials of the BEPhEM magazine for the entire period of its publication (1886–1917) allows us to draw such conclusions.

1. The materials of the magazine about famous domestic and foreign scientists and specialists in the field of natural sciences and mathematics were both biographical and prosopographical in nature. Moreover, the motives for the appearance of such publications were, as a rule, “round” dates from the moment of birth, from the beginning of creative activity, from the moment of publication of an important work, or from the moment of death (or the fact of death) of the subject of the publication. We tentatively classified all similar articles in the magazine as follows: a) brief biographical and prosopographical notes; b) detailed biographical and prosopographical articles; c) obituaries.

2. The total volume of biographical and prosopographic materials for the entire period of publication of the magazine was equal to 462.7 pages, which was 2.88% of the total volume of the magazine. At the same time, the magazine contained materials about 84 scientists (only biographical publications were considered; published articles by scientists, their details are open, and the characteristics of the tasks they solved were not taken into account). The largest journal volume of editorials (more than 5 pages for each) was provided by 27 scientists (Fig. 1; this amounted to 336.3 pages or 72.7% of the total volume of biographical material; this group included 9 domestic scientists (volume materials – 103.8 pages) and 18 foreigners (volume of materials – 232.5 pages,

which made up 69.1% of the total number of materials of this group of articles)). In general, the editors allocated an average of 4.89 pages for each domestic scientist, and 5.89 pages for each foreign scientist. For obvious reasons, the largest volume of materials was about mathematicians (35.44% of the total volume of biographical materials) and about physicists (46.42%).

3. The results of the content analysis allow us to draw a conclusion about the high quality of the published biographical and prosopographical materials of the magazine. This was greatly facilitated by the careful selection of authors of articles (or sources of materials), as well as special requirements of the editors to document sources of materials in page references.

4. The “inattention” of the magazine’s editors to a whole series of “round dates” of famous domestic and foreign mathematicians and physicists, as well as the uneven volumes allocated by the magazine for biographical studies, testify to the absence of a clear editorial policy in the matter of allocating printed volumes for systematic biographical statements and research.

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Conflicts of interest.

The authors declare no conflict of interest.

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Біографічні матеріали математиків і природодослідників у “Віснику дослідної фізики та елементарної математики” (1886–1917 рр.): змістовний і контентний аналіз

Анотація. У статті представлені результати дослідження особливостей біографічних та просопографічних матеріалів про відомих математиків та дослідників природи, опубліковані в одному з найбільш авторитетних журналів “Вісник дослідної фізики та елементарної математики”, який видавався в Києві та Одесі протягом 1886–1917 рр. Фактично журнал був неофіційним періодичним друкованим органом математичного відділення Новоросійського товариства дослідників природи. Мета дослідження – проведення змістовного та контентного аналізів текстів статей журналу, в яких розкриваються

біографії, особливості трудової діяльності та участь у наукових дослідженнях відомих вчених. При цьому авторами стосовно змістовного аналізу предмету дослідження використовувалися наукові методи – аналізу та синтезу, узагальнення і систематизації. У процесі проведення кількісного контентного аналізу використовувалися квантифікація тексту, збирання емпіричних даних, їх узагальнення та математико-статистична обробка. У результаті проведеного дослідження біографічних матеріалів журналу протягом зазначеного періоду його автори дійшли таких висновків. По-перше, матеріали журналу про відомих вітчизняних і зарубіжних математиків і дослідників природи носили як біографічний, так і просопографічний характер. Причому мотивами появи таких публікацій, як правило, були “круглі” дати з моменту народження, початку творчої діяльності, з моменту виходу важливого твору або з моменту смерті (або факт смерті) суб’єкта публікації. Усі подібні статті в журналі умовно класифіковані авторами на короткі біографічні та просопографічні нотатки, розгорнуті біографічні та просопографічні статті, некрологи. По-друге, загальний обсяг біографо-просопографічних матеріалів за період видання журналу становив 2,88 % від загального обсягу журналу. При цьому журнал містив матеріали про 84 вчених. Найбільший журнальний обсяг редакцією (більше 5 сторінок для кожного) був наданий 27 вченим і це склало 72,7 % від загального обсягу біографічного матеріалу; до цієї групи потрапили 9 вітчизняних учених та 18 іноземців. На кожного вітчизняного вченого у загальному розрахунку редакція виділяла в середньому 4,89 сторінки, а на кожного іноземного – 5,89 сторінки. Найбільший обсяг матеріалів був про фізиків (46,42% від загального обсягу біографічних матеріалів) та про математиків (35,44%). По-третьє, результати змістовного аналізу дозволяють зробити висновок про високу якість друкованих біографо-просопографічних матеріалів журналу. Цьому сприяв ретельний відбір авторів статей (чи джерел матеріалів) і особливі вимоги редакції до документування джерел у посторінкових посиланнях. По-четверте, “неуважність” редакції журналу до цілого ряду “круглих дат” знаменитих вітчизняних та зарубіжних математиків та фізиків, а також нерівномірні обсяги, що виділялися журналом для біографістики, свідчать про відсутність чіткої редакційної політики журналу щодо виділення друкованих обсягів для систематичних біографічних заяв та досліджень.

Ключові слова: біографія; просопографія; змістовний аналіз; контент-аналіз; математики; дослідники природи

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Science, Technology and Innovation (STI) ecosystems in Indonesia (1945–2021): A historical policy analysis

Abstract. *The aim of this research is to study the policy efforts conducted by the Indonesian government since the beginning of independence in 1945 to present, in advancing science and technology and innovation. By the mid 2019, the President of Republic of Indonesia Joko Widodo had stipulated Law No. 11/2019, concerning the National System of Science and Technology. This regulation served as an efforts from the Indonesian government to build the science and technology and innovation ecosystem lies in terms of strengthening innovation policies. The implication of this policy mandates that the National Research and Innovation Agency serves as the only research and innovation institution owned by the Government of Republic of Indonesia. Efforts in establishing the science and technology ecosystem and innovation have been initiated since the era of President Soekarno (1945–1965), which was further continued in the leadership of the next president. The aforementioned efforts are additionally described in this study from the perspective of policy history. A content analysis approach is employed to identify each stipulated regulation in Indonesia in the form of Laws, Government Regulations, Presidential Regulations, Presidential Decrees, and Presidential Instructions. There are 78 regulations in the field of science and technology and innovation that are analyzed. The results of the analysis are described based on the emergence of regulations and institutional implications generated as part of the ecosystem. Based on the results of field findings and analysis, there are five periods of formation of a research and innovation ecosystem in Indonesia, namely 1) The Era of Foundation Ladders and Pioneers of Science and Technology Systems and Innovation (1945–1966), 2) Era of National Strategic Industrial Project Development (1966–1998), 3) Era of Restructuring the National System of Research, Development, and Application of Science and Technology (1998–2004), 4) the era of awakening the National Innovation System (2004–2014), and 5) The Era of Integration of the National Research and Innovation System (2015–2024).*

Keywords: *STI Policy; STI Ecosystem; Historical of Policy; historical policy analysis; STI Institutions; Regulatory and institutional frameworks*

Introduction.

Science and technology and innovation are of paramount instruments in measuring competitiveness as well as in inclusive and sustainable economic growth for a country, such as in America (Padilla-Pérez & Gaudin, 2014), European continent (Karo, 2011), African continent (Saidi & Douglas, 2018), and in developing countries (Chaurasia & Bhikajee, 2016). Developing countries require policy support in the development of appropriate science and technology and innovation, to captivate and master the science and technology and innovation to encourage growth for their countries (Niosi, 2010). For a country such as Indonesia, an integrated policy is deemed

pivotal that places science and technology as well as other related sectors in a common policy corridor, such as the health and food sector (Mustangimah et al., 2021).

The Government of Republic of Indonesia has crafted efforts to establish the science and technology and innovation ecosystem, even if referring to a number of literatures, efforts have been initiated since the era of President Sukarno. However, it was not until 2002 that Indonesia had a law-level regulation that provides regulation on science and technology and innovation through Law Number 22 concerning the National System of Research, Development, and Application of Science and Technology (Sisnas P3Iptek). Sisnas P3Iptek served as a reference in the development of science and technology and innovation in Indonesia for almost 17 years, before replaced by Law Number 11 of 2019 concerning the National System of Science and Technology.

Based on the above conditions, this research navigated specific policy efforts conducted by the Indonesian government from the beginning of independence in 1945 to the present. So, the formulation of the research questions (R.Q) is as follows: R.Q. = How to policy efforts conducted by the Indonesian government since the beginning of independence in 1945 to advance science and technology, and innovation?

Research methods.

Therefore, the identify regulations in Indonesia since the beginning of independence through a content analysis approach (Hall & Steiner, 2020; Pramana et al., 2021; Putera et al., 2022), obtaining the 78 regulations with details as follows: 1 regulation in the form of Provisional People's Consultative Assembly Decree of Republic of Indonesia, 28 regulations in the form of Law of Republic of Indonesia, 19 regulations in the form of Government Regulation of Republic of Indonesia, 13 regulations in the form of Presidential Regulation of Republic of Indonesia, 14 regulations in the form of a Presidential Decree of Republic of Indonesia, and 4 regulations in the form of Instruction of the President of Republic of Indonesia. Furthermore, these regulations are mapped and analyzed by regarding the type of regulation emergence and the institutional implications generated as part of the ecosystem. Policy history description (Sharkansky, 1995; Taylor, 1998) or acknowledged as historical policy analysis (Hanberger, 2003) in this research, is utilized as an effort to navigate the government's paces in forming, establishing, and strengthening the science, technology and innovation ecosystem in Indonesia. At the same time, such efforts are utilized to observe the alignment of national leadership (president tenure) in constructing the science, technology and innovation ecosystem.

Results and discussion.

To reveal the strategic phases of the national leadership in Indonesia in advancing science and technology and innovation, a mapping of policies related to science, technology and innovation was conducted since the beginning of independence (1945). Science, technology and innovation have long been a concern of public policy researchers, including studying innovation systems (Miller, 2016).

The Era of Founders and Pioneers of Science, Technology and Innovation Systems (1945–1966).

The period of President Sukarno's administration (1945–1965) was regarded as the toughest effort to establish a system of science, technology and innovation in Indonesia. In the early days of independence in 1948, the *Organisatie Voor Natuurwetenschappelijk Onderzoek (ONO)* was formed which later changed its name into the *Natural Sciences Research Organization (OPIPA)*. The establishment of this scientific institution is expected to coordinate research activities proliferated across many institutions and departments at that time. This effort was unexpectedly less successful; the Ministry of Education, Teaching and Culture in 1950 further considered establishing the *Academie van Wetenschappen* which was also less successful (*Panitia Penyusun Naskah Buku 20 Tahun Indonesia Merdeka (Committee for Drafting the Book of 20 Years of Independent Indonesia)*, 1966).

Dated on March 19, 1956, Law Number 6 of 1956 was stipulated concerning the *Indonesian Science Council (MIPI)*. The existence of this policy was instrumental as it provided a concrete step taken by the government to abolish all national scientific bodies inherited from the Dutch colonial government, further reshaping it as a scientific institution of the Indonesian government. MIPI was constructed as an effort to implement Article Number 40 of the Provisional Constitution, established as an assigned body (coordinating center) in guiding efforts to advance science in the territory of Republic of Indonesia. Additionally, MIPI was formed as an effort to advance and guide science fulfilling national principles that protect the freedom to pursue science by referring to the national as well as peace and mankind principles, executing its tasks under the Ministry of Education, Teaching and Culture.

Interestingly, the composition of MIPI's membership is regulated based on the MIPI Law, which means that one-half of the members must consist of experts in one of the sciences of the first group and one-half of the second group. This second group includes religious experts, for example scholars who are regarded as well-known experts in other religions (religions recognized by the Government).

MIPI was born amidst the difficult circumstances, because research as a national effort had to be conducted with inadequate scientific facilities. Efforts to gather strength from all experts in the field of science from all regions of Indonesia were conducted by holding the *National Science Congress I* in Malang, taken place in 1958. At the congress, President Sukarno stated that 'A just and prosperous society cannot be held without the proper use of science' (*Committee for Drafting the Book of 20 Years of Independent Indonesia*, 1966).

In 1960, initiating a new step at the stage of development planning in the field of science, technology and innovation was included in the Decree of the Provisional People's Consultative Assembly of the Republic of Indonesia Number II/MPRS/1960 on the *Outlines of the Planned Universal National Development Pattern for the First Stage (1961-1969)*. In this policy, the government places research as an important part of the pattern of national development, and research policies were adapted to a free and active foreign policy involving the people without leaving scientific requirements. In

Appendix A, the mental/religious/spiritual/research areas of the Provisional People's Consultative Assembly Decree Number II/MPRS/1960 mentioned that:

“MIPI will therefore soon be retooled into a National Research Agency. It is better if there is only one highest scientific institution in Indonesia. At the same time, it should be noted that as long as research institutions, proliferating in the Government are not retooled, their efficiency remains in doubt. MIPI, which was expected to be the only highest scientific institution, did not or had not succeeded in positioning itself”. (MPRS and Ministry of Information, 1961, p. 69)

In 1961 along with the dynamics of changes in government, initially MIPI was under the Minister of Education, Teaching and Culture. However, due to changes in the Cabinet nomenclature, which was the Department of Basic Education and Culture, and the Department of Higher Education and Science, MIPI was under the Department of Higher Education and Science. Changes re-occurred in 1962 through Presidential Decree Number 94 of 1962 concerning the New Regrouping Structure of the Working Cabinet, in which the Department of National Research Affairs (Durenas) was formed in the Working Cabinet III and was classified in the Production sector, included in the Development Compartment. The existence of Durenas did not replace the existence of MIPI and also the functions of the Department of Higher Education and Science (Department of Information, 1970).

At the beginning of its formation, this Department was led by the Minister and assisted by three assistant ministers, which included: a) Assistant Minister for National Research for Policy Affairs, b) Assistant Minister for National Research for Executive Affairs, and c) Assistant Minister for National Research for Scientific Administration. The existence of Durenas and MIPI provided a new dynamic in the management of research in Indonesia, one of the major steps taken is the construction of research facilities which include:

1. The Durenas and MIPI Complex in Jakarta, in accordance with Presidential Instruction Number 5 of 1964, dated on April 11, 1964, stipulated that this complex was erected on Jalan Gatot Subroto Jakarta, on an area of 31 hectares, which was originally intended for the International Exhibition and Fair Institute. On this land would be built: Durenas Building, MIPI Building, Clearing House and Printing Center Building, Marine Research Institute Building, National Scientific Documentation Center Building, Science Museum, Natuurhistorisches Museum, Employee Housing, Civic Center and a power plant (Committee for Drafting the Book of 20 Years of Independent Indonesia, 1966).
2. Cibinong National Research Center Complex, was built in 1963 on an area of 200 ha land. However, the groundbreaking was conducted on September 1964 by Deputy Prime Minister III, Dr. Chaerul Saleh planned for the National Institute of Chemistry, National Institute of Physics, National Institute of Metallurgy, National Electronics Institute, National Scientific Aircraft Center, and National Institute of Economics and Society. To immediately execute the research, the National Chemical Institute and the National Electronics Institute were placed at the Bandung Institute of Technology (ITB) due to a

shortage of scientific equipment. Meanwhile, the National Institute of Economics and Society has initiated to conduct its activities in Jakarta (Committee for Drafting the Book of 20 Years of Independent Indonesia, 1966).

3. The National Biology Institute in Bogor comprising all the facilities such as buildings and laboratories was transferred from the Ministry of Agriculture Affairs. The National Biological Institute at that time, consisted of the Botanical Gardens with branches in Cibodas, Purwodadi, Bali, North Sumatra and West Sumatra, the Botanical Research Institute, Herbarium Bogoriense, the Zoologicum Bogoriense Museum, and the Marine Research Institute (Committee for Drafting the Book of 20 Years of Independent Indonesia, 1966).

In 1966, President Sukarno issued Presidential Decree Number 63 of 1966 regarding the composition of the Dwikora Cabinet which was further refined. This change made the Department of National Research Affairs into a National Research Institute under the Deputy Prime Minister for Political Institutions along with the Atomic Energy Institute, the National Front, Uppenas, and the Institute for the Development of Revolutionary Spirit, as well as the National Defense Institute.

During this period, the government has developed space research projects, such as the Early Scientific and Military Rocket Project (PRIMA) affiliated with the Indonesian Air Force and the Bandung Institute of Technology. The PRIMA project succeeded in building and launching two Kartika I series rockets and their telemetry in 1964 (Sumatri, 2014), and culminating with the establishment of the National Institute of Aeronautics and Space through Presidential Decree Number 236 of 1963.

In addition, President Sukarno's concern with nuclear power was immense, actualized by the establishment of the State Committee for Radioactive Investigations in 1954. The State Committee had the task of investigating the possibility of radioactive fallout from nuclear weapons tests in the Pacific Ocean (Faqih et al., 2014). By prioritizing the development of atomic energy utilization for the welfare of society; then through Government Regulation Number 65 of 1958, dated on December 5, 1958, the Atomic Energy Council and the Atomic Energy Institute (LTA) were formed, which were later refined into the National Atomic Energy Agency (BATAN) based on Law Number 31 of 1964 concerning the Basic Provisions of Atomic Energy. In addition, several research, development, and engineering (R&D) facilities were established across various areas, including the Bandung Nuclear Area (1965) and the Pasar Jumat Nuclear Area, Jakarta (1966).

Efforts to give appreciation are additionally conducted, through Presidential Regulation Number 27 of 1960 on Scientific Prize Giving. This effort was conducted to encourage the ability of its citizens in participating, advancing and developing science for the benefit of the community, nation and state. The scientific prize is generally granted to a person or community whose scientific work includes: a. a new discovery or improvement of an old invention, either by personal or other's invention; b. an advancement and development of science; c. benefits for the progress and

prosperity of the Indonesian nation in particular, and for the mankind in general. (Presidential Decree No. Republic of Indonesia Number 5 /1965).

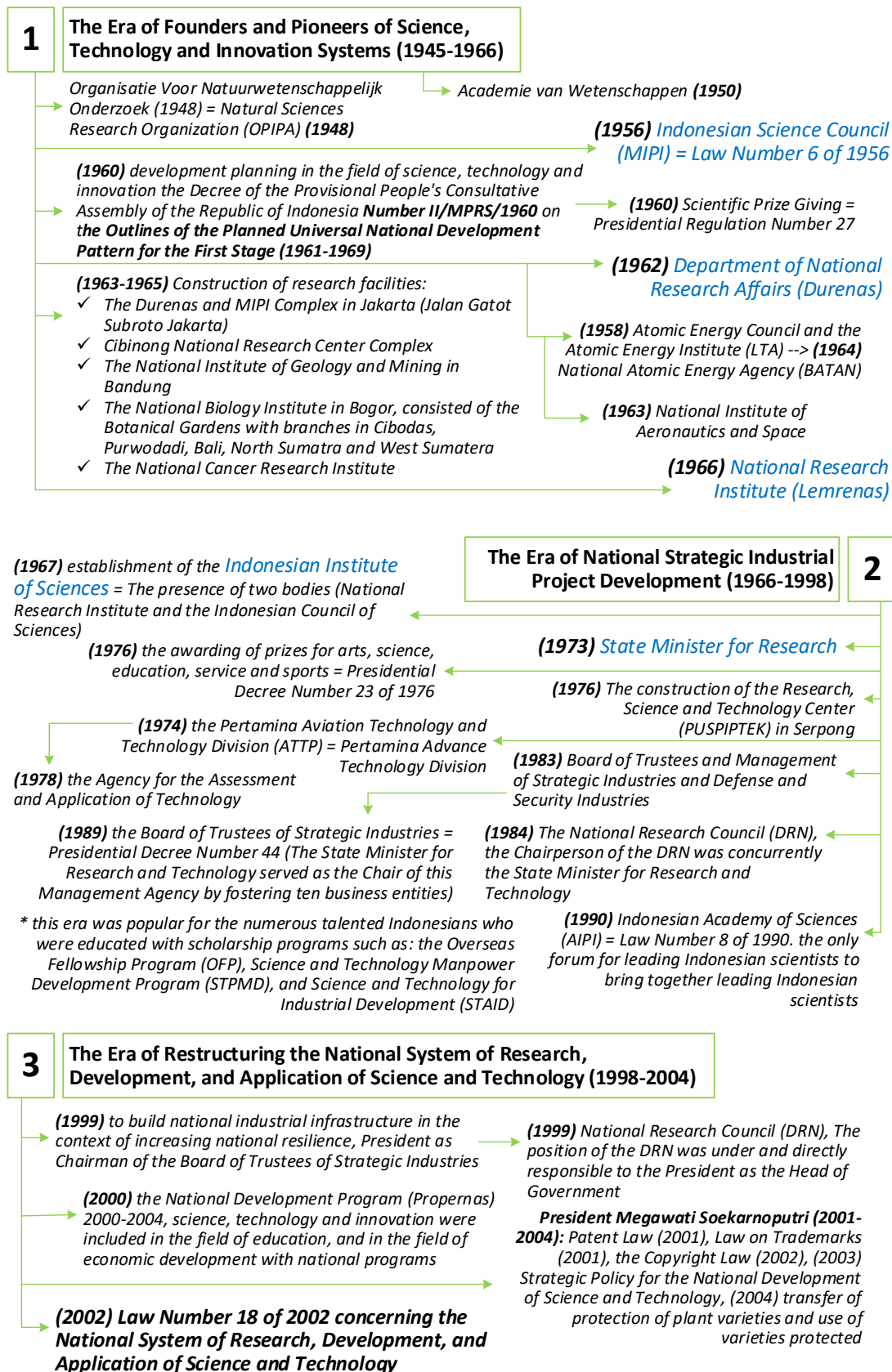


Figure 1. The strategic steps of the national leadership for science, technology and innovation in Indonesia, period 1945–2004.

The Era of National Strategic Industrial Project Development (1966–1998).

Continuous efforts during the President Soeharto's tenure were evident by the launch of science, technology and innovation programs at the beginning of the government, with the formation of the Ampera cabinet. In this cabinet, the positions of the National Research, and the National Atomic Institute were outside the cabinet since the Ampera cabinet conducted policy politics, where the ministerial elements in the cabinet assisted the president in accomplishing daily tasks (Simanjuntak, 2003).

The presence of two bodies (National Research Institute and the Indonesian Council of Sciences) was terminated which both conducted the national research tasks, thus the Provisional People's Consultative Assembly issued the Decree of the Leadership of the Provisional People's Consultative Assembly Number 18/B/1967 dated on February 16, 1967 concerning the dissolution of the National Research Institute and the Indonesian Council of Sciences, and the establishment of the Indonesian Institute of Sciences. The aim was to simplify state institutions and to create efficiency and effectiveness in the implementation of national research tasks. The establishment of the Indonesian Institute of Sciences was a synthesis of the two previously existing bodies and later became the central body working in the field of science in Indonesia. Even the Decree of the Leadership of the Provisional People's Consultative Assembly Number 18/B/1967 mandated that the Indonesian Institute of Sciences; in addition to its functions, it should be upgraded to become the Indonesian Academy of Sciences which will be established by law.

The Acting President of the Republic of Indonesia further issued Presidential Decree Number 128/1967 concerning the Establishment of the Indonesian Institute of Sciences on August 23, 1967. After observing the results, the deliberations of the National Research Institute and the Indonesian Council of Sciences and research institutions was held on April 21–22, 1967 in Bandung.

In addition, the Indonesian Institute of Sciences was entrusted with the authority to organize coordination, integration and synchronization at the central and regional levels in the fields of technology and science. Institutionally, the Indonesian Institute of Sciences (LIPI) consists of the Chair, the Indonesian Science Trustees Board, the Deputy Chairperson of LIPI, and the Secretary of LIPI. The Deputy Chairperson of LIPI is divided into three fields, including: 1) Deputy Chair for Natural Sciences in charge of the National Biology Institute, National Geology and Mining Institute, and National Cancer Institute, 2) Deputy Chair for Technology in charge of the National Chemical Institute, National Physics Institute, Metallurgical Institute National Institute of Electrical Engineering, National Instrumentation Institute, and National Scientific Documentation Center (Indonesian Institute of Sciences, 1968).

In further developments, in the Development Cabinet II, there was again the Minister who coordinated research activities, who was referred to as the State Minister for Research. This is in accordance with Presidential Decree No. 9/1973. This task area was regarded pivotal to accelerate and expedite the implementation of development. Especially research activities that can produce concrete results that can be immediately applied to upsurge the development outcomes, in agriculture, industry, or other fields.

The existence of the State Minister for Research reduces the functions and duties of LIPI. Since then, two government agencies have been running similar function. Even when the Development Cabinet III (1978–1983), the Government added the function of the State Minister of Research to become the State Minister in charge of handling research and technology issues, the development and implementation were more focused and integrated in accordance with development needs, as the State Minister of Research and Technology (Simanjuntak, 2003).

The government's efforts in accelerating the development on a technology basis were proven by appointing Prof. Dr. Ing. B. J. Habibie as a government advisor in the field of advance technology and aviation technology who was directly responsible to the president. This appointment was based on Decree No. 76/M/1974 dated on January 5, 1974, and at the same time establishing the Pertamina Aviation Technology and Technology Division (ATTP). ATTP was later changed to Pertamina Advance Technology Division. This unit was later transformed into the Agency for the Assessment and Application of Technology based on the Decree of the President of the Republic of Indonesia Number 25 of 1978 concerning the Agency for the Assessment and Application of Technology, and was renewed through Presidential Decree Number 31 of 1982.

Hence, the government established a Board of Trustees and Management of Strategic Industries and Defense and Security Industries based on Presidential Decree Number 59 of 1983. The Board of Trustees of Strategic Industries served as an inter-departmental coordinating body whose main task was to perform the development and management of strategic industries in an integrated, efficient and effective manner. There are four industries that are included in the guidance of this board, conveying: a) PT. Krakatau Steel, b) PT. Indonesian Telecommunication Industry, c) Company Company PT. Nurtanio, and d) Company Company PT. Indonesian PAL.

Provisions regarding the Board of Trustees of Strategic Industries have been refined through Presidential Decree Number 44 of 1989. This Presidential Decree required the formation of the Strategic Industry Management Agency, tasked with technically fostering and developing strategic industries; thus technology, productivity and efficiency in their implementation is eligible to support national development and independence of the State's defense and security, to coordinate the implementation of policies for the management of industries that are environmentally friendly, and to oversee the implementation and management of strategic industries. The State Minister for Research and Technology served as the Chair of this Management Agency by fostering ten business entities.

The emergence of a new institution in 1984 was in accordance with Presidential Decree Number 1 of 1984 concerning the National Research Council. The National Research Council (DRN) was a non-structural coordination forum that prepared the formulation of the main national programs in the field of research and technology, which was under and directly responsible to the State Minister for Research and Technology. Interestingly, the Chairperson of the DRN was concurrently the State Minister for Research and Technology; meanwhile the Deputy Chair was in rotation between the Chairs/Heads of Non-Departmental Government Institutions under the

coordination of the State Minister for Research and Technology or the Head of the Department of Research and Development, whose implementation was further regulated by the State Minister for Research and Technology as the Chairperson of the DRN; and the Secretary of the DRN served as the Assistant State Minister for Research and Technology in the Coordination of Policy Formulation and Evaluation and the National Main Program of Research and Technology. Hence, elements of DRN members from representatives of Departments, Non-Departmental Government Institutions, Universities, and other scientists were deemed necessary and in accordance with needs.

Institutional dynamics in this period improved along with the issuance of Law Number 8 of 1990 regarding the Indonesian Academy of Sciences. The existence of the Indonesian Academy of Sciences (AIPI) in this Law was different from the spirit of the Decree of the Leadership of the Provisional People's Consultative Assembly Number 18/B/1967 expecting AIPI as a form of transformation from LIPI. AIPI was based on Law Number 8 of 1990 which was the only forum for leading Indonesian scientists to bring together leading Indonesian scientists and to provide opinions, suggestions, and considerations on their own initiative and/or requests regarding the mastery, development, and utilization of science and technology to the Government and society in achieving national goals.

In addition, the Government also established a Research, Science, and Technology Center through Presidential Decree Number 43 of 1976. The construction of the Research, Science and Technology Center (PUSPIPTEK) was conducted on land that has been controlled by the Government on behalf of the National Atomic Energy Agency located in Serpong, Tangerang Regency, and could be expanded as required. PUSPIPTEK serves as a means for the implementation of: a. a focused and integrated research to facilitate the implementation of national development; b. a fulfillment of the scientific community by improving awareness of the general public regarding the role of research, science, and technology in development.

An interesting note from this period, since the late 1970s, Suharto through B. J. Habibie has targeted and developed the ten high-tech industries acknowledged as the development of national strategic industries, such as: aircraft, shipbuilding, railways, telecommunications, electronics, steel and goods and machine stuff. The most famous part of this program was the development of the aircraft industry in Bandung (Okamoto & Sjöholm, 2003). However, these programs were immediately destroyed one by one before the economic crisis in 1997. As stated by Hill (1995), Indonesia's science and technology policies since the late 1970s illustrated that high-tech projects did not always lead to the development of broad-based and efficient technologies, especially when the underlying research, education and technical infrastructure was feeble (Hill, 1995). In addition, this era was popular for the numerous talented Indonesians who were educated with scholarship programs such as: the Overseas Fellowship Program (OFP), Science and Technology Manpower Development Program (STPMD), and Science and Technology for Industrial Development (STAID) (Isma'il & Mulyanto, 2003).

Era of Restructuring the National System of Research, Development, and Application of Science and Technology (1998–2004).

During the reign of B. J. Habibie (1998–1999), not much effort was performed to promote the growth of the innovation ecosystem in Indonesia. In addition to his short reign and high political transition, B. J. Habibie focused more on reforming the government sector. However, the idea and desire to establish a science and technology system and innovation remained the goal, such as through issuing Presidential Decree No. 40 of 1999 to build national industrial infrastructure in the context of increasing national resilience, which was obligatory to cultivate superior technology-based industries that were strategic in nature. Even engaging the President as Chairman of the Board of Trustees of Strategic Industries, with the State Minister of Research and Technology/Head of the Agency for the Assessment and Application of Technology as Chief/Chairman of the Daily Executive.

In addition, B. J. Habibie finalized the National Research Council (DRN) through Presidential Decree Number 94 of 1999. DRN was designated as a non-structural institution that assisted the government in formulating a national science and technology development strategy, as well as the formulation and implementation of research activities according to the demands of the times. The position of the DRN was under and directly responsible to the President as the Head of Government.

President B. J. Habibie had issued Presidential Instruction Number 33 of 1998, addressed to Rachmat Saleh, Economic Advisor in the Banking Sector to study and convey his views and suggestions for funding through the capital market mechanism for the former strategic industries as referred to in Article 2 paragraph (1) of Presidential Decree Number 44 of 1989 concerning the Strategic Industry Management Agency. The issuance of this decree indicated that B. J. Habibie still had a hope to navigate the solutions for the existence of strategic industries.

The next era was under the leadership of President Abdurrahman Wahid (1999–2001), having the National Development Program (Propernas) 2000–2004 through Law Number 25/2000. This era also succeeded in providing regulations for: 1) Protection of plant varieties (Law No 29 of 2000), 2) Trade Secrets (Law Number 30 of 2000), 3) Industrial Design (Law Number 31 of 2000), and 4) Layout Design of Integrated Circuit (Law Number 32 of 2000). In addition, this policy provides recognition of intellectual property.

The leadership era of President Abdurrahman Wahid also paid attention to national standardization (Government Regulation Number 102 of 2000), soil damage control for biomass production (Government Regulation Number 150 of 2000), Fertilizer for plant cultivation (Government Regulation Number 8 of 2001), and the application and development of appropriate technology (Presidential Instruction Number 3 of 2001). In this era, the Board of Trustees of the Strategic Industry which was formed based on Presidential Decree Number 40 of 1999 and the Secretariat which was formed to support the implementation of the duties of the council, was declared dissolved through Presidential Decree Number 45 of 2000.

Furthermore, the national leadership was carried out by President Megawati Soekarnoputri (2001–2004). The beginning of the leadership of President Megawati

Soekarnoputri was marked by the birth of the Patent Law (Law Number 14 of 2001). This step was occupied in line with Indonesia's ratification of international treaties, the rapid development of technology, industry and trade, which was compulsory to have a Patent Law providing reasonable protection for Inventors. The equivalent step was also performed by allotting the Law on Trademarks (Law Number 15 of 2001). One year later, the government issued Law Number 19 of 2002 concerning the Copyright. This step was regarded as an effort to protect ethnic and cultural diversity as well as wealth in the arts and literature with developments that require copyright protection for intellectual property generated from such diversity.

This era recorded important achievements in the field of science, technology and innovation policies in Indonesia, with the issuance of Law Number 18 of 2002 concerning the National System of Research, Development, and Application of Science and Technology. This policy aimed to strengthen the carrying capacity of science and technology for the purpose of accelerating the achievement of state goals, as well as increasing competitiveness and independence of the state in international relations. Furthermore, the science and technology institutions in the policy consist of elements of universities, R&D institutions, business entities, and supporting institutions.

Additionally, the government dispensed Presidential Instruction Number 4 of 2003, which is in accordance with the provisions of Article 18 paragraph (2) of Law Number 18 of 2002 concerning the National System of Research, Development, and Application of Science and Technology, constituting that the Government is obliged to formulate the direction, main priorities, and the Government's policy framework in the field of science and technology as outlined in the Strategic Policy for the National Development of Science and Technology.

In addition, President Megawati Soekarnoputri paid attention to the development of types and standards of plant cultivation tools and machines (Government Regulation Number 81 of 2001), by securing the domestic industry due to the surge in imports as part of the implementation of the commitment to trade liberalization within the framework of the Agreement Establishing the World Trade Organization. Her efforts were conducted through reducing tariffs and eliminating non-tariff barriers (Presidential Decree Number 84 of 2002); the policy of actualizing the availability of food that is sufficient, safe, quality, nutritious and diverse as well as steadily distributed throughout Indonesia and affordable by people's purchasing power (Government Regulation Number 68 of 2002); transfer of protection of plant varieties and use of varieties protected by the government (Government Regulation Number 14 of 2004); food policy that is safe, quality and nutritious is very important for the growth, maintenance and improvement of health status as well as increasing public intelligence (Government Regulation Number 28 of 2004).

In fact, President Megawati Soekarnoputri issued Presidential Instruction Number 3 of 2003. This policy was implemented in order to expedite the information and communication technology in the government process (e-government), as well as to increase efficiency, effectiveness, transparency and accountability of government administration. In this era, PUSPIPTEK was reorganized into the duties and functions

of the State Minister for Research and Technology (Presidential Decree Number 49 of 2003)

The Era of Awakening the National Innovation System (2004–2014).

Policies in the field of research and innovation in the first period of President Susilo Bambang Yudhoyono (2004–2009) were pursued to increase the capacity of science and technology with policies directed at: (1) increasing the focus and capacity of research and development on science and technology; (2) accelerating the process of diffusion and utilization of science and technology products; (3) strengthening science and technology institutions; and (4) creating a climate of innovation in the form of incentive schemes. (Presidential Regulation Number 7/2005)

In the second period, President Susilo Bambang Yudhoyono (2010–2014), had a vision of “The realization of a prosperous, democratic and righteous Indonesia”. In the formulation of people's welfare, the government was committed to realizing an increase in people's welfare, through economic development based on competitive advantage, wealth of natural resources, human resources and national culture. This important goal was managed through the advancement of mastery of science and technology. In the second period of leadership, President Susilo Bambang Yudhoyono implemented a science and technology development strategy with two development priorities, covering: 1) enhancement of the National Innovation System (NIS) which functions as a vehicle for science and technology development towards a long-term vision of science and technology development, and 2) improvement of Research, Development, and Application of Science and Technology carried out following the directions outlined in the RPJPN 2005–2025 (Presidential Regulation Number 5 of 2010).

As a commitment to implement the National Innovation System, the government of the era of President Susilo Bambang Yudhoyono emphasized that the National Innovation System served as a chain network among public institutions, research and technology institutions, universities and the private sector in an institutional arrangement that was systemic; and in long term, it can encourage, support, and synergize activities to produce, utilize, engineer innovations in various sectors, and implement and disseminate the results on a national scale where the real benefits of innovative findings and products are fairly distributed to the community (Presidential Regulation of the Republic of Indonesia Number 32/2010). In addition, the Presidential Regulation Number 32/2010 was also issued on the Master Plan for the Acceleration and Expansion of Indonesia's Economic Development (MP3EI) 2011–2025. This regulation prioritized the competitiveness as a goal, “to complete the planning document in order to increase the competitiveness of a more solid national economy, it is therefore necessary to have a master plan for the acceleration and expansion of Indonesia's economic development which has a clear direction, the right strategy, focus and measurable”. One of the concepts promoted in MP3EI lies in the Innovation Initiative 1-747, becoming the main driver of the innovation-based economic system transformation process through strengthening the education system (human capital) and technological readiness.

Era of Research and Innovation National System Integration (2015–2024).

In the era of President Joko Widodo's administration (2015–2024), efforts to build the science and technology and innovation ecosystem were emphasized by the issuance of the Law on Science and Technology Systems on August 13, 2019. The National System of Science and Technology in this policy was mentioned as a pattern of relationships that shaped the planned, directed, and measurable, and sustainable linkages between institutional elements and resources to build a network of science and technology as a unified whole in supporting the implementation of science and technology and as a scientific basis in the formulation and stipulation of national development policies (Law Number 11 of 2019).

Furthermore, it was disclosed that to carry out research, development, study, and application, as well as integrated inventions and innovations, a national research and innovation agency was formed. In the explanation of Law Number 11 of 2019, it was also mentioned that what was acknowledged by 'integrated' was an effort to direct and synergize, among others, in the preparation of plans, programs, budgets, and Science and Technology Resources in the fields of Research, Development, Assessment, and Application to produce Inventions and Innovations as scientific foundations in the formulation and determination of national development policies.

This regulation, on the other hand, provided for the regulation of the mobility of Science and Technology human resources, such as the placement of Science and Technology human resources from research and development institutions and/or assessment and application institutions belonging to the Central Government or Regional Governments to Business Entities (Article 72 Paragraph (2) letter C, Law Number 11 of 2019).

The government in 2017 issued a policy for the establishment of a professionally managed vehicle to develop and encourage sustainable economic growth through the development, application of science and technology, and the growth of technology-based start-ups. This vehicle was later acknowledged as the Science and Technology Park (Presidential Regulation of the Republic of Indonesia Number 106 of 2017). Initially, the government was committed to building 100 Science and Technology Parks proliferated throughout Indonesia (Presidential Regulation of the Republic of Indonesia Number 2 of 2015).

President Joko Widodo attempted to develop a cooperation scheme between research and development institutions and all stakeholders of Construction Services, to protect intellectual property on construction materials and equipment as well as to construct technology resulting from domestic research and development (Law Number 2 of 2017), during this period there were also published national policies in the field of research acknowledged as the National Research Master Plan (RIRN). RIRN served as a guideline for ministries/institutions/regional governments and stakeholders to formulate action plans in the implementation of National Research. RIRN contains the vision, mission, objectives, targets, national research strategies, and national research planning (Presidential Regulation of the Republic of Indonesia Number 38 of 2018).



Figure 2. The strategic steps of the national leadership for science, technology and innovation in Indonesia, period 2005–2021.

Conclusions.

The strategic steps of the national leadership for science, technology and innovation have been evident from the regulations issued during the presidential reign, grouped into five eras (Figure 1 & Figure 2). This merit is based on the issuance of policies and implications for science and technology institutions and innovation as part of the dynamics of the science, technology and innovation ecosystem. The era of grouping is summarized as follows: First, The Era of Foundation Ladders and Pioneers of Science and Technology Systems and Innovation (1945–1966). This era was under the leadership of President Sukarno. Second, Era of National Strategic Industrial Project Development (1966–1998). This era was under the leadership of President Suharto. Third, Era of Restructuring the National System of Research, Development, and Application of Science and Technology (1998–2004). Although the period of this era merely lasted for seven years, there were three presidents who led this era, including: President B. J. Habibie (1998–1999), President Abdurrahman Wahid (1999–2001), and President Megawati Soekarnoputri (2001–2004). This era however succeeded in giving birth to Law Number 18 of 2002 concerning the National System of Research, Development, and Application of Science and technology. Fourth, the era of awakening the National Innovation System (2004–2014) led by the President Susilo Bambang Yudhoyono, establishing an innovation system in Indonesia. Fifth, The Era of Integration of the National Research and Innovation System (2015–2024), under the

era of President Joko Widodo's administration marked by the presence of the Ministry of Research, Technology and Higher Education (2014), further changed into the Ministry of Research and Technology/National Research and Innovation Agency (2019), and later altered to the National Research and Innovation Agency (2021).

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The authors declare no conflict of interest.

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Національне агентство з досліджень та інновацій, Індонезія

Наука, технології та інновації (НТІ) екосистем в Індонезії (1945–2021): історико-політичний аналіз

Анотація. Метою цього дослідження є вивчення політичних зусиль уряду Індонезії з початку незалежності в 1945 році до сьогодні, спрямованих на розвиток науки, технологій та інновацій. До середини 2019 року Президент Республіки Індонезія Джоко Відодо затвердив Закон № 11/2019 про Національну систему науки і технологій. Ця постанова стала результатом спроб уряду Індонезії побудувати науково-технічну та інноваційну екосистему з точки зору зміцнення інноваційної політики. Наслідки цієї політики передбачають, що Національне агентство досліджень та інновацій є єдиною дослідницькою та інноваційною установою, що належить уряду Республіки Індонезія. Зусилля щодо створення науково-технологічної екосистеми та інновацій були розпочаті з часів президента Сукарно (1945–1965), які були продовжені під керівництвом наступного президента. Вищезазначені зусилля додатково описані в цьому дослідженні з точки зору історії політики. Підхід аналізу вмісту використовується для ідентифікації кожного нормативного акту в Індонезії у формі законів, урядових постанов, президентських постанов, президентських указів та президентських інструкцій. Проаналізовано 78 нормативно-правових актів у сфері науково-технічної та інноваційної діяльності. Результати аналізу описані на основі появи нормативних актів та інституційних наслідків, створених як частина екосистеми. На підставі результатів польових досліджень та аналізу можна виділити п'ять періодів формування дослідницької та інноваційної екосистеми в Індонезії, а саме: 1) Ера початку фундаментальних досліджень науково-технічних систем та інновацій (1945–1966), 2) Ера розвитку національного стратегічного промислового проекту (1966–1998), 3) Ера реструктуризації національної системи досліджень, розробок і застосування науки і технологій (1998–2004), 4) Ера пробудження національної інноваційної системи (2004–2014), 5) Ера інтеграції національної науково-інноваційної системи (2015–2024).

Ключові слова: політика в області НТІ; система НТІ; історія політики; аналіз історичної політики; інститути НТІ; нормативно-правова та інституційна база

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The practice of borrowing foreign projection and technological solutions in the design of electrical machines in Ukraine in the second half of the 1930s

***Abstract.** This article, based on the problem-chronological, comparative-historical, historiographical, and source-research methods, as well as the method of actualization, identifies the extent of borrowing foreign design and technological solutions in the Ukrainian Soviet Socialist Republic for projecting electrical machines in the second half of the 1930s, as well as the reasons for the absence of unambiguous information in historiography regarding the existence of this phenomenon in the republic at this chronological stage. The publication provides a general assessment of the quality of scientific support for the processes of creating electrical machines, establishes the ways of fulfilling the scientific-technical borrowings that were studied and the dynamics of their development, analyzes their role in the growth of the technical level of products of the Ukrainian electrical machine-building branch. It was found that the level of a scientific escort for electrical machine-building production in Ukraine during the considered period was insufficient for arranging a completely independent design of the entire range of sectoral industrial products, therefore, scientific and technical borrowings remained the only way to maintain the necessary rates of development in the design and production of new types of electrical machines across the entire latitude spectrum of their application. According to the archival documents, it was found that because of the rapid growth of the Soviet Union's needs at the turn of the 1930s–1940s for electric power equipment, on the one hand, and the improvement of the possibility of organizing its mass production in Ukraine, on the other, the scale of such borrowings grew like an avalanche. At the same time, because of the growth of the scientific-technical potential of the republican electrical machine-building, the nature of the procedure for their fulfillment at the end of the 1930s changed and allowed their mimicry as the exclusively independent achievements of domestic designers. This is how the achievements of Ukrainian electric machine*



builders were presented to the entire Soviet society during the considered period, which subsequently allowed them to gain a foothold in the relevant historiography, however, the facts and arguments in this publication completely refute this established opinion.

Keywords: *electrical machine-building; scientific-technical potential; scientific-technical cooperation; scientific support; industrialization; power electrical equipment*

Introduction.

By the beginning of World War II, the Soviet electrical machine-building in all indexes was still lagging behind similar branches of the leading industrial states; however, it achieved significant success in mastering new types of products. During the 1930s, in the Ukrainian segment of this all-union branch of industry, a series of modernized, less material-intensive electric motors were introduced into production in the power range of previously produced machines, and the range of new electric machines was significantly expanded (Alexandrov et al., 1957). At the same time, Soviet historiography either directly states that the modernization of produced and design of new electric machines since 1932 by Ukrainian specialists was carried out without foreign scientific-technical assistance (Alexandrov et al., 1957, p. 311; Suzdaltsev et al., 1965, pp. 75–77), or the facts of such assistance are not mentioned at all, regardless of the period of development of the Soviet electrical machine-building development in general or Ukrainian in particular (Gusev, 1955; Martynuk, 1958). The post-Soviet historiography of the national electrical machine-building industry does not mention the involvement of foreign scientific and technical assistance in the development of electrical machines in the Ukrainian Soviet Socialist Republic (UkSSR, Ukrainian SSR) in the second half of the 1930s (Glebov, 1999; Tverytnykova, 2009), however, its absence is not approved too. A study by the American historian A.C. Sutton asserts that Ukrainian electrical machine builders used foreign scientific and technical assistance in the design of electrical machines during the 1930s, but the latest date for such direct cooperation is 1935 (Sutton, 1971, p. 154). Under direct cooperation, this researcher implies work for scientific and technical assistance agreements concluded between the Soviet government and foreign companies for the provision of such assistance to specific Soviet manufacturers of electrical machines. Generally, according to his data, the receipt of indirect foreign scientific-technical assistance, at least from *General Electric (GE)*, by Ukrainian electrical machine builders continued until the 1940s, although he does not specify the form of this assistance (Sutton, 1971, p. 165).

Thus, as historiographical analysis shows, current information about the practice of foreign scientific and technical borrowings made by Ukrainian electrical machine builders in the development of their electrical machines in the second half of the 1930s is incomplete and rather contradictory. This point makes it impossible to determine the real degree of independence of the scientific support of the Ukrainian electrical

machine-building during the study period, which updates the presented publication. In this regard, this article aims at establishing the scale of borrowings of foreign design and technological solutions in the Ukrainian SSR when designing electrical machines in the second half of the 1930s, as well as the reasons for the absence in historiography of unambiguous information regarding the existence of this phenomenon in the republic during the chronological period under consideration. To achieve this purpose, it is necessary to determine the overall quality of scientific support for the processes of creating electric machines in the UkSSR during this period in the context of the possibility of organizing their completely independent projecting. Also, it is required to establish the ways of making the scientific-technical borrowings, that have been researched, assess the dynamics of their development, and analyze their role in the growth of the technical level of products of the Ukrainian electrical machine-building.

Research methods.

In preparing the publication, problem-chronological, comparative-historical, historiographical, and source-study methods were used, as well as the method of actualization. The combined use of these methods allowed: a) to determine the reasons for the gaps made by previous researchers in the coverage of the issue raised; b) to restore the general historical picture regarding the quality of the scientific support of the Ukrainian electrical machine-building industry that existed during the period under study; c) to establish the scale, role, and place of scientific and technical borrowings in the approach to the design of electrical machines practiced in the second half of the 1930s in Ukraine.

Results and discussion.

First, it should be noted that because of the specifics of the pre-revolutionary path of development of national electrical engineering, it was deprived of its scientific support, and scientific-technical escort for the processes of creating electrical machines was carried out from abroad (Anniukov, 2014, p. 37). After the final establishment of Soviet power in Ukraine in 1921, the republican government did not pay due attention to the development of local electrical machine-building, since this industry fell within the competence of the government of Soviet Russia. As for Moscow, it was decided to give priority to strengthening the potential of electrical machine-building enterprises of the capital of the Russian Soviet Federative Socialist Republic (RSFSR) and Petrograd, while the restoration of the industrial capacities of the largest in the Union of Soviet Socialist Republics (USSR) Kharkivskii elektromekhanicheskii zavod [Kharkiv Electromechanical Plant] (*KhEMZ*) began only in 1924 (The State Archive of Kharkiv Region [SAKhR], 1924). Thus, until the mid-1920s, actions to organize their own scientific support for the processes of creating electrical machines in the UkSSR were carried out on a scale limited solely by the initiative of higher technical educational institutions located in the republic, without any significant support from the government and industry sectoral management. Meanwhile, the rapidly developing

electrification of the national economy of the USSR, by this time, demanded the quantity and range of electric machines never produced by the domestic industry. Considering the complete unpreparedness of the Ukrainian segment of the Soviet electrical machine-building for such a turn of events, the government of the USSR adopted and successfully carried out activities to introduce American constructions of electrical machines and American technologies of their production on German equipment, into the Ukrainian electric machine industry (Anniukov, 2020a). This became possible thanks to the agreement on scientific-technical cooperation concluded in 1925 between the State Electrotechnical Trust of the USSR (*GET*) and the German Allgemeine Elektrizitäts Gesellschaft (*AEG*), which come into effect in 1926 (Novikov, 2006, p. 16). The success was ensured because a few years earlier an identical event was brilliantly carried out by *AEG* itself, which had concluded a scientific and technical cooperation agreement with *GE* (Sutton, 1968, p. 189).

Meanwhile, the undertaken activities did not change the essence of the scientific support of the processes of creating electric machines, which existed in the pre-revolutionary period on the territory of the UkSSR, aimed at producing duplicates of foreign constructions manufactured using foreign technologies. As an attempt to avoid consolidating the duplication of foreign machine designs and technologies for their manufacture as the basic concept of organizing scientific escort in the branch, in 1927, the UkSSR began to lay the foundations for a system of its own scientific support for national electrical machine-building. So, on October 1, 1927, on the initiative of the *KhEMZ* engineer and part-time teacher of the Kharkiv Technological Institute (*KhTI*) A. Ya. Berger, the Bureau of Research of Synchronous Machines (The Central State Archive of the Supreme Authority and Administration of Ukraine, 1932) was organized in the plant. The task of this Bureau was to learn from *AEG*'s design and technological experience in designing appropriate electrical machines. However, this company provided with either modernized pre-war (before World War I) own designs, or adapted copies of American machines, which significantly hampered the work of Ukrainian specialists to determine the modern fundamental principles of projecting electrical machines (Anniukov, 2020b, p. 142). The second factor hampering this work was the shortage of relevant specialists, since the purposeful training of designers of electrical machines in the UkSSR began only in 1930 (Anniukov, 2020b, p. 144).

In 1929, a direct agreement on scientific and technical cooperation between *GET* and *GE* was signed, which resulted in Ukrainian electrical machine builders receiving not German copies of American machine designs, but the original, although not the newest, project documentation (Sutton, 1968, p. 191). This significantly increased the level of competence of soviet developers of electrical machines, since it allowed them to deal directly with the modern achievements of electrical machine-building, and not with their interpretations. For a more detailed study of the American experience in the projecting of electrical machines at *KhEMZ*, which by that time had secured the status of the basic profile enterprise in the Ukrainian SSR, bureaus and laboratories were created, where factory specialists analyzed those technical solutions adopted at *GE* in

the design of electric machines, the essence of which was not disclosed by American manufacturers. However, these factory scientific-technical divisions, besides those mentioned earlier, were not permanent structures, part of the joint technical office of *KhEMZ*, and were created only for (and for a period) the solution of some specific technical and technological problems (Annienkov, 2016a, p. 48). This situation was caused by the fact that until 1934 *KhEMZ* was not an independently operating economic entity (although it had an internal trust structure of organization), but was a production unit in the *GET* system, and then in the *Vsesoyuznoie elektrotekhnicheskoe obiedineniie* [All-Union Electrotechnical Association] (*VEO*), which replaced the latter (*SAKhR*, 1934). Therefore, the creation of our own systemically organized scientific escort of production processes for a rather long period was outside the competence of the heads of *KhEMZ*, and *GET* and *VEO* considered the scientific-technical support provided to the plant by their subordinate research centers in Moscow and Leningrad to be sufficient.

Thus, until 1934, the own research divisions at *KhEMZ* were formed only on the principles of in-plant initiative, and their work was not coordinated systematically. To eliminate this shortcoming in organizing scientific escort and its factory structure of scientific support processes of creating electrical machines at *KhEMZ*, at the request of the People's Commissariat of Heavy Industry, to the position of chief-electrician was seconded a professor of the Leningrad Polytechnic Institute and chief-electrician of the Leningrad plant *Elektropribor* M. P. Kostenko (Kartsev, 1981). Under his leadership, a systematic scientific support of production was organized at *KhEMZ* before 1937, but not yet staffed with a qualified personnel resource, since the necessary influx of graduates of higher educational institutions trained in the relevant specialties began only in the second half of 1934, and before that, the opposite process of outflow of specialists from the plant was observed (*CSASAAU*, 1935). That is, until the end of the 1930s, there was no effective scientific support for the creation of electric machines at *KhEMZ*, or at least sufficient to completely abandon scientific-technical borrowings in their projecting. Taking this into account, as well as the fact that *KhEMZ* was the main and largest electrical machine-building enterprise in Ukraine during the period under review, we can assume the information available today in the relevant historical studies about the final transition of the Ukrainian segment of the core industry in the second half of the 1930s to independent projecting of electrical machines such that do not correspond to the actual historical events that took place.

Referring to archival documents confirms the above assumption since it follows that the termination of the scientific and technical cooperation between *KhEMZ* and *GE* in 1932 was due not to the Soviet Union's refusal of foreign scientific and technical assistance, but to the establishment of such cooperation with the British Metropolitan-Vickers (*MV*) according to the contract of April 14, 1931, on large-scale seven-year scientific-technical assistance concluded between *MV* and *VEO* (*SAKhR*, 1931). Moreover, after the reverse reorganization of *VEO* into *GET* with changes in the status of *KhEMZ* and similar to its large electrical machine-building enterprises of the USSR

(Annikov, 2015), this contract was renegotiated on November 14, 1935, and *KhEMZ* was given the opportunity by direct [rather than through the branch management structures, as it had been before] access to the design and technological documentation of this subsidiary of the American *Westinghouse*, as well (according to the same form of the appropriate agreement) as of the Italian company *Ansaldo* (SAKhR, 1936b). Under contracts with *MV* and *Ansaldo*, the scientific and technical employees of *KhEMZ* were trained at the electrical plants of these companies to improve their qualifications. However, at the same time, highly qualified specialists were sent to these enterprises too, who were charged by the plant administration with the obligation at the place of the "internship" to in any way seize any information regarding by projecting of electrical machines that was not received by *KhEMZ* according to agreements on scientific-technical assistance (SAKhR, 1937e). To sum up, in the second half of the 1930s, Ukrainian electrical machine builders actively practiced borrowings of foreign design and a technological solution that were fulfilled without sanction of their authors. To maximize the effect of such activities in the USSR, special teams were formed comprising 8–10 research engineers, whose work profile was of the greatest current interest to the management of the enterprises they represented. For example, as of the summer of 1937, such profiles for *KhEMZ* were the works in the following areas: particularly large and particularly small DC machines, explosion-proof and acid-resistant electric machines, silent electric motors, an AC ship electric drive (SAKhR, 1937e). The relevant scientific and technical workers of this plant were included in the profile group of specialists seconded abroad, formed by the GET from representatives of all those interested in mastering the production of these types of products of the USSR enterprises.

It should be noted that not only researchers were involved in the above activity but also technical specialists of the commercial departments of *KhEMZ*, seconded abroad by the plant to carry out the acceptance of those components purchased from foreign manufacturers for the electric machines *KhEMZ* produced. For example, in the summer of 1937, the USSR received a loan from Great Britain to purchase a wide range of electric drives for metal-cutting machine tools and their components from British manufacturers. To accept these products under the order of the Soviet government, *KhEMZ* sent specialists who were charged, among other things, "... by all available means to refresh all the drawing and informational material on the Soviet machine-tool electrical equipment ...", providing a detailed list of priority issues in projecting of electrical machines for metal-cutting equipment (SAKhR, 1937). The very fact of receiving components for machine-tool electric machines manufactured by *KhEMZ* from abroad indicates that the latter were designed on the basis of borrowed scientific-technical solutions. At the same time, the cited requirements for seconded employees confirm that several of these solutions were never reproduced by the factory specialists until the end of the 1930s.

The above and similar points mentioned in archival documents give us grounds to assert that, despite the creation of its system of scientific support by 1937, *KhEMZ*

did not acquire significant independence in the development of electric machines by that time, and in this matter, still needed foreign help. This is also evidenced by the presence in the plant's structure management office of the appropriate division – Bureau of Foreign Technical Assistance (SAKhR, 1937d). In addition, this fact was confirmed in 1938 in his voluminous [11 sheets] service note on the role of foreign scientific-technical assistance in the development of *KhEMZ* by deputy director and at the same time chief engineer of the plant M. N. Shevchenko, who analyzed in sufficient detail both the results obtained from such cooperation and its future prospects. Even though this document, in typical Soviet stylistics of the study period, presented the achievements of Ukrainian electrical engineering in terms of machine design in a hypertrophied form, the role of borrowings foreign scientific-technical solutions in this process is disclosed quite objectively. Thus, M.N. Shevchenko, whose competence cannot be questioned, absolutely directly claims that further (after 1938) independent projecting of electrical machines by the Ukrainian sector of the profiled industry, in principle, has already become possible, but only in the product range that is already mastered in production, and new machines sizes without the use of foreign ready-made scientific and technological solutions by domestic specialists cannot be created, which requires the continuation of the practice of concluding agreements on technical assistance with foreign, primarily American, electrical companies (SAKhR, 1938c).

The need for *KhEMZ* to conclude agreements on scientific-technical assistance with foreign electrical companies, as the basic one in the USSR (since 1934) enterprise for manufacturing electrical machines for the Navy and artillery (Annikov, 2019a), was discussed also in a top-secret note provided in 1939 by the USSR Artillery Research Marine Institute to the Armament and Supply Directorate of the Workers and Peasants Navy of the USSR. So, the 1st rank military engineer A.P. Konoplev pointed out in this document that the USSR completely lacked experience in designing ship and artillery AC electric machines, which, because of their extreme prevalence in modern weapons in an approaching war, requires the prompt organization of foreign scientific-technical assistance to *KhEMZ* in the development of this type of machine from American and French electrical companies (SAKhR, 1939). This problem of lack of experience was complicated by the fact that during the period under study there were no uniform standards for parameters of current for electrical-energy systems of ships and artillery units in the USSR, which led to many significantly differenced mechanical platforms in technical characteristics of even the same type of weapons (SAKhR, 1937a). Therefore, to avoid the need for massive alterations of mechanisms, both those already in service and those under construction, it was necessary to design an extremely wide range of AC electric drives, with each size of drives must be meeting the already existing tactical-technical characteristics of the mechanical units of the corresponding weapon systems. This point in preparation of the USSR for a big war required such a pace of design of these electric machines, which neither Ukrainian nor Soviet electric machine builders as a whole could provide even theoretically, which made foreign scientific-technical assistance in this matter extremely demanded.

Thus, in the projecting's context of the latest electric machines for the Ukrainian segment of the core industry, the need to conclude agreements on scientific-technical cooperation with leading manufacturers of electrical machines remained relevant throughout the second half of the 1930s. Meanwhile, the agreement on scientific-technical assistance with *MV* was concluded only until April 15, 1938 (SAKhR, 1937f), after which the practice of scientific-technical cooperation, carried out under such contracts, was not applied by *KhEMZ*. At least, no evidence of this was found in archival documents. However, this does not mean at all that Ukrainian electrical machine builders, after 1938, refused to borrow foreign scientific-technical solutions when designing electrical machines. As the war was approaching, foreign companies were reluctant to share not only that scientific-technical information that could improve the tactical-technical characteristics of the weapons produced by the USSR, but also that contributed to strengthening the scientific-technical potential of the Soviet industry as a whole (SAKhRF, 1938c). Thus, the conclusion of agreements on comprehensive technical assistance between the Soviet government and leading foreign electrical engineering companies began to lose its information attractiveness and economic feasibility. Therefore, since 1938, Ukrainian electrical machine-building have been developing the previously approved methods of unauthorized borrowing of scientific-technical information from its foreign owners, mostly carried out during the acceptance by *KhEMZ* employees of the components domestic electromachines, which were purchased from their manufacturers abroad. This fact, among other things, led to an abrupt increase in the number of *KhEMZ* employees sent abroad to accept products and components, which is revealed by the corresponding graph in Figure 1.

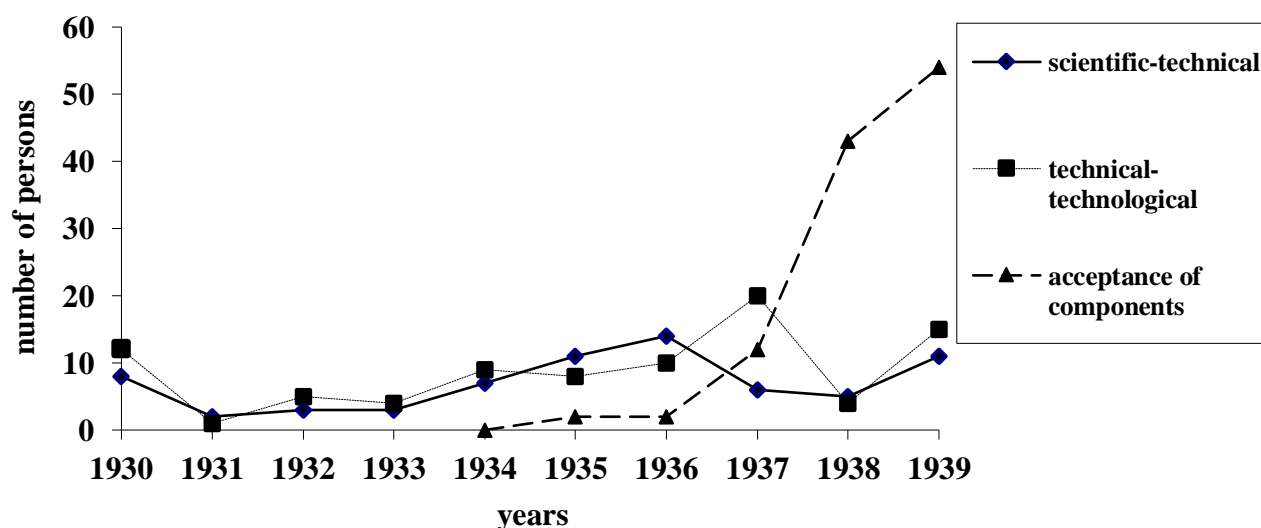


Figure 1. Dynamics of the number of *KhEMZ* employees seconded to foreign enterprises during the 1930s to get acquainted with scientific, technical, and technological achievements, as well as to accept components.

In general, the graphs presented in figure 1 were compiled based on the results of the analysis of cases with information about the *KhEMZ* employees seconded abroad, stored in the fund of the plant in the state archive of the Kharkiv region (SAKhR, 1936b). These graphs reveal that the number of scientific and technical employees of the plant sent to borrow design solutions for electric machines steadily increased from 1931 to 1936 (especially during 1933–1936). During the same period, the number of engineers sent to carry out borrowing of technologies for the production of electrical machines increased too, although in this case, unlike the previous one, the nature of familiarizing Ukrainian specialists with foreign technological achievements had a more frequent change of the periods of growth and reduction in the number of corresponding business trips. This is explained by the fact that the very process of introducing new types of electric machines into production during the study period in Ukraine proceeded stepwise, which, on the one hand, was determined by the method of economic management adopted in the USSR, and on the other, by the insufficient level of development of the scientific component of the branch scientific-technical potential.

So, the demand and supply for new types of electric machines, according to the Soviet method of organizing the work of the industry, were established by the government in a directive way, indicating specific dates of commencement: their production – to the designated manufacturer and use – to all (also designated) consumers. This procedure alone excluded the evolutionary transition from piece-by-piece to mass production of new types of serial electric machines as lean effective ways of using them and optimal technologies for their production were mastered. Accordingly, the evolutionary development of production technologies was excluded too, at least in manufacturing non-unified units and parts, the proportion of which in new types of machines is always especially large. However, the own forces of scientific support of electrical machine-building in the Ukrainian SSR during this period, albeit developed at an increasing pace, were still only mastering the general principles of projecting DC machines, therefore, they could not provide the required technologies for their mass and serial production overnight, much less could not provide such technologies for the production of AC machines. This moment, when receiving government directives regarding the mastering of new types of machines by Ukrainian manufacturers, caused the need to urgently borrow these technologies from foreign manufacturers of originals, which was duplicate by the Ukrainian electrical machine building industry, and, as a result, to an increase in the number of seconded domestic specialists for these purposes.

Along with the above, it is worth noting that the information assimilated by Ukrainian scientific-technical specialists on the principles of projecting DC electric machines allowed them to start independent development of individual models of equipment from 1934, mainly for military purposes (Anniukov, 2016b; Anniukov, 2017; Anniukov, 2019a; Anniukov, 2019b). Since these electric machines were designed according to foreign prototypes, they used mostly borrowed scientific-technical solutions, and, consequently, they copied parts and whole units of the original

designs. However, at the time of placing the corresponding military orders for already designed machines, not all of them had been mastered in production by national electrical machine builders. Therefore, since 1934, we can observe the emergence of such a phenomenon as seconding technical employees of *KhEMZ* abroad to accept components manufactured by foreign electrical companies by order of this plant for the electric machines it produces. By 1936, the volume of borrowed scientific-technical information on the principles of projecting DC machines, as well as the number of competent specialists, reached the level that allowed Ukrainian electrical machine builders to independently modernize foreign prototypes on a large scale and develop new models of electrical machines on their basis. This factor influenced the gradual reduction in the number of people seconded to get acquainted with foreign scientific-technical achievements in the projecting of DC electric machines presented in figure 2, which by 1938 led to a reduction in this kind of business trips as a whole. However, as for AC machines, the achievements of Ukrainian creators of electrical machines were much more modest, as a result, since 1939, the number of domestic specialists seconded to foreign electrical engineering companies began to grow again, this time – to borrow experience in projecting this type of electrical machines.

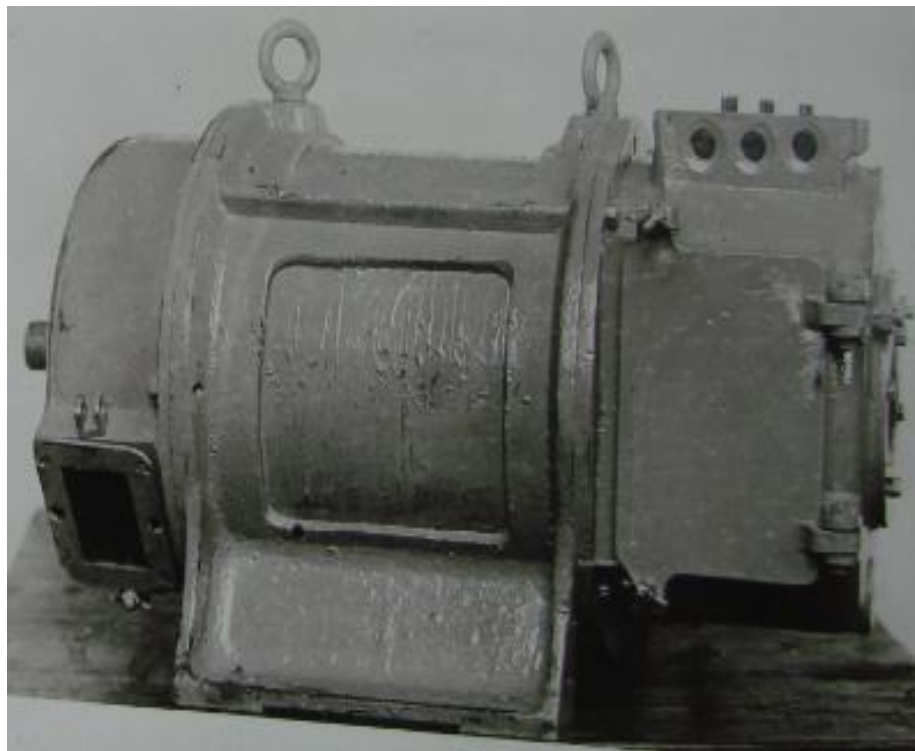


Figure 2. A DC motor of the MDP type, created at *KhEMZ* for automated drive systems for artillery mechanisms in 1938, based on design and technological principles borrowed from MV (SAKhR, 1937b).

Despite the above progress in scientific support for the production of DC electric machines in the Ukrainian segment of the Soviet electrical machine-building during the first half of the 1930s, the rate of creating an effective organization of design and

development works by 1937 lagged significantly behind the growth rate of the needs of the national economic complex of the country for such a technique. Therefore, the practice of producing duplicates of foreign designs in the Ukrainian electrical machine-building for DC electric machines was continued, which caused another increase in the number of business trips of *KhEMZ* engineering-technical personnel to borrow technologies for their mass and serial production. By 1938, the plant managed to organize outstripping projecting of DC electric machines in most of the range of their standard sizes and versions that existed at that time, and the need to borrow multiple technologies for their serial production disappeared, since the relevant knowledge accumulated by plant specialists was supplemented with the time sufficient for their implementation. Thus, in 1938, the number of *KhEMZ* engineering-technical personnel seconded abroad to borrow production technologies decreased to the level of 1933–1934, as well as scientific-technical personnel – to borrow design solutions.

Meanwhile, an increase in the number of self-designed DC electric machines in Ukraine caused a rise in the volume and range of purchases of their components abroad, since, because of the circumstances given in this article, units and parts by foreign manufacturers were still widely used in the designs of domestic machines. The organization of our own production of such components was not always expedient or even possible at all. Before 1939, the plant technological services were engaged in accelerated production of as many duplicates of DC electric machines as possible due to the soon expiry of the term of scientific and technical assistance contracts, and they were not able to carry out technological preparation of production of those components which were not included in the design of duplicated machines. Therefore, to avoid disruption of the schedule for the development of analogs of foreign DC electric machines in production in general, it became more expedient to purchase components of machines developed in the Ukrainian SSR from their foreign manufacturers, which were not mastered by the domestic electrotechnical industry. Wherein, a fairly large part of the separate specific units of electric machines could not have been projected at all by Ukrainian developers, since they had just mastered the corresponding methods. These circumstances influenced the fact that starting from 1936 we can observe a rapid growth of *KhEMZ* employees seconded to foreign electrical engineering enterprises in order to carry out the acceptance of the components purchased by the plant from them.

By 1939, besides the above reasons, the growing number of employees seconded abroad by *KhEMZ* abroad was influenced by organizing the production of a wide range of AC machines at the plant. However, at that moment, the conclusion of agreements on scientific-technical cooperation between the Soviet electrical machine-building industry and foreign companies in the previous form of providing comprehensive scientific-technical assistance was no longer practiced. As a result, the geographic scope and nature of the activities of Ukrainian electrical machine builders seconded abroad have changed. So, while in 1935–1938, British electrical engineering enterprises accounted for an average of 84% of all *KhEMZ* employees seconded abroad, then since 1939, only 21%, for the USA this figure remained unchanged at

2.5%, and for Germany, it changed from 8% up to 54%, respectively. In addition to the Italian electrical machine-building industry, as an alternative to the above-mentioned main donor countries of relevant scientific-technical knowledge, since 1938, electrical engineering enterprises of France, Switzerland, and Sweden became involved in cooperation with the Ukrainian core branch. As a result, the analyzed indicator for countries other than Great Britain, Germany, and the United States has changed from an average of 5.5% in 1935–1937 up to 22.5% in 1938–1940. At the same time, it should be recognized that in the overwhelming majority of cases during 1939–1940, foreign scientific-technical assistance to Ukrainian electrical machine builders was limited to the supply of components, which also led to an increase in the number of *KhEMZ* employees seconded to accept them, as can be seen in the graph in Figure 1 (SAKhR, 1937f; SAKhR, 1938a; SAKhR, 1938b; SAKhR, 1941a).

Meanwhile, the expansion of the geography of suppliers of components indicates an increase in the number of design solutions borrowed by *KhEMZ* abroad when projecting its models of electric machines. However, since 1939, these borrowings were carried out by the scientific-technical personnel of *KhEMZ*, mainly not at enterprises-manufacturing, but at their research base. To do so, initially, scientific-technical employees of *KhEMZ*, as well as other industry research centers and factories, were seconded abroad to study there the range of produced electric machines in the line of operational parameters of interest to the USSR. After they had chosen the optimal models of machines, the Soviet government, depending on the situational circumstances, purchased the latter both in single copies and in batches, and to accept this equipment on the previously mentioned principle, special groups of seconded employees of the *KhEMZ* were formed. Once at the manufacturing plant, these groups tried to glean any information of a scientific-technical and planning-economic nature regarding not only the purchased equipment but generally for the entire range of products manufactured by such an enterprise, thus increasing own arsenal of corresponding knowledge. Upon delivery of the purchased electric machines, their individual copies were dismantled and additionally studied in the research laboratories of *KhEMZ* to adapt their designs as a whole or only their components of interest to the enterprise to the existing production technologies at the plant, as well as to clarify the modernization potential of the purchased models of machines. Much attention when conducting this kind of research in the USSR at the turn of the 1930s–1940s was paid to identifying the possibilities of replacing scarce non-ferrous metals, the production of which in the required volumes in the country by the beginning of World War II had not been established (SAKhR, 1941c).

The given methodology of scientific and technical borrowings directly follows both from the assignments for business trips posted in those archival materials, on the basis of which the graphs in Figure 1 were built, and from the instructions to employees seconded abroad, as well as to the administrative staff of the industry forming the relevant groups, previously given in this article. In addition, individual elements of this methodology are displayed in archived tasks for the purchase of specific foreign

samples of electric machines for their subsequent copying, as well as archived plans for the study of such samples (SAKhR, 1936a). While in a secret report to the chief engineer of *KhEMZ* A. I. Bertinov, the head of the Special Design and Technological Department of this plant for the projecting of military electrical engineering H. G. Vaisman listed the companies [*GE, Westinghouse, Clark Cooper, Hammer*], at which electric machines were purchased on purpose for for the subsequent full-scale copying of the units and mechanisms used in them when creating a range of electrical machines of repeated short-term conditions of operation for the Workers-Peasants Red Fleet of the USSR, and also briefly described the methodology used for this and the results of its application (SAKhR, 1940). In their totality, all the available relevant archival materials allow us to assert that after 1938, copying of scientific and technical solutions used by them in the design of electrical machines, unauthorized by foreign manufacturers, became the main way of corresponding borrowings carried out by Ukrainian electrical machine builders.

At the same time, it should be recognized that, in contrast to the previous period of wide and more open scientific and technical cooperation with foreign electrical firms, since 1938, the practice of borrowing technologies for the production of electrical machines by direct or modified copying from the original manufacturers has almost ceased to be applied in the UkSSR. This was replaced by the practice of borrowing technologies for performing individual material-processing operations from those foreign enterprises where they were performed in the most optimal version for Ukrainian electrical machine builders, which, of course, did not include only electrical machine-building plants. Therefore, by 1939, the number of foreign enterprises of interest to the Soviet electrical machine-building, in terms of the material-processing technologies used there, had increased, and since it was rather difficult and time consuming to obtain them in the required volumes solely by unauthorized means, they were mostly borrowed on a purposeful short-term contractual basis. As a result of these circumstances, the number of *KhEMZ* technologists seconded abroad to get acquainted with production technologies by 1939 again began to outstrip the number of seconded designers. However, the predominant transition of Ukrainian specialists at the turn of the 1930s 1940s from borrowing the general principles of projecting electric machines to borrowing specific design and technological solutions in their development, as well as the transition to mostly independent copying of foreign originals, with their simultaneous modification and modernization, testified to the significantly increased quality of the scientific component of the branch scientific-technical potential compared to the first half of the 1930s.

Conclusions.

Contrary to the opinion established in the historiography of the Soviet and Ukrainian electrical machine-building, neither in 1933 nor in 1935, as it is presented in the relevant historical studies, the transition in the industry under study to a fully independent product projecting did not and could not happen at all. The main obstacle

to abandoning the leading role of foreign scientific-technical solutions in the projecting of domestic electrical machines in the second half of the 1930s was the lack of effective own scientific escort for the processes of making such technique. Thus, the material-technical, organizational, and personnel components of the scientific support system for the creation of electric machines were finally formed only by 1938 at their main manufacturer in the republic – *KhEMZ*. At the same time, the experience in projecting DC machines, in the entire range of their then use, has not yet been fully gained by the plant until the beginning of the 1940s, and in the part of AC machines, it absented almost completely. Thus, scientific-technical borrowings remained the only way that allowed the Ukrainian electrical machine-building to maintain the necessary rates of mastering new types of electric machines in the projecting and production across the entire spectrum of their application, dictated by the chosen rates of industrialization of the USSR. As World War II unfolded, the pace of industrialization of the USSR further accelerated, which directly influenced the formation of spasmodic growth dynamics in the scale of borrowing from abroad the relevant design and technological solutions in the Ukrainian segment of the Soviet electrical machine-building. At the same time, with increase the quality of scientific support for the processes of creating electrical machines in the UkSSR, domestic projectors at the turn of the 1930s–1940s made a transition from duplicating foreign projects of machines as a whole to compilation projecting. In addition, during this period, the number of unauthorized borrowings of constructive solutions that were carried out by Ukrainian electrical machine builders from foreign manufacturers increased significantly. Also, as preparations for the war progressed, the degree of confidentiality of information about foreign business trips of Ukrainian specialists in electrical machine-building grew, which, combined with the two previous factors [secrecy in the carried out of borrowings and compilability on their subsequent implementation] allowed the Soviet government, for political reasons, to successfully simulate the transition of the national industry to a completely independent projecting of electrical machines before the public. The ideological necessity of presenting the socialist way of conducting the national economy as the most effective, which persisted throughout the entire period of the USSR's existence, influenced the fact that Soviet historians did not need to reconstruct the real picture of the scientific support of the domestic electrical machine building in the late 1930s. Thus, the myth spread by the Soviet government at that time about the complete refusal of the industry to borrow foreign design and technological solutions in the projecting of electrical machines was finally entrenched in the relevant historical works.

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Conflicts of interest.

The author declare no conflict of interest.

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Практика запозичень зарубіжних конструкторсько-технологічних рішень при проектуванні електричних машин в Українській РСР у другій половині 1930-х років

Анотація. У статті, на ґрунті проблемно-хронологічного, порівняльно-історичного, історіографічних та джерелознавчих дослідницьких методів, а також методу актуалізації, визначені масштаби проваджених в Українській Радянській Соціалістичній республіці запозичень зарубіжних конструкторсько-технологічних рішень при проектуванні електричних машин у другій половині 1930-х років, а також причини відсутності в історіографії однозначної інформації стосовно існування даного явища в республіці на цьому хронологічному відтинку. В публікації надана загальна оцінка якості наукового забезпечення процесів створення електричних машин, встановлені шляхи здійснення досліджуваних науково-технічних запозичень і динаміка їхнього розвитку, проаналізована роль цих транзакцій у зростанні технічного рівня продукції українського електромашинобудування. Встановлено, що рівень наукового супроводу електромашинобудівного виробництва в Україні впродовж розглянутого періоду був недостатнім для організації повністю самостійного проектування всієї номенклатури галузевої продукції, тому науково-технічні запозичення залишалися єдиним шляхом, що дозволяв підтримувати необхідні темпи освоєння в проектуванні та виробництві нових типів електромашин по всій широті спектру їх застосування. На базі архівних документів з'ясовано, що у зв'язку зі стрімким зростанням потреб Радянського Союзу на рубежі 1920-х – 1930-х років в електросиловому устаткуванні з однієї сторони і покращенням спроможності організації його масового випуску в Україні – з іншої, масштаби таких запозичень збільшувалися лавиноподібно. Разом з тим, завдяки зміцненню науково-технічного потенціалу республіканського електромашинобудування, характер процедури їх здійснення наприкінці 1930-х років змінився і дозволив їх мімікрію під виключно незалежні розробки вітчизняних проектувальників. У такому вигляді протягом досліджуваного періоду досягнення українських електромашинобудівників представлялися всьому радянському суспільству, що дозволило цьому наративу закріпитися у відповідній історіографії, утім розміщені в даній публікації факти та аргументи повністю спростовують цю усталену думку.

Ключові слова: електромашинобудування; науково-технічний потенціал; науково-технічне співробітництво; наукове забезпечення; індустріалізація; силове електроустаткування

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**Mastering and development of industrial production of rolling stock in Ukraine
(1991–2022)**

***Abstract.** The article attempts to investigate the historical circumstances of the mastering and development of the industrial production of rolling stock in Ukraine from 1991 to 2021. The aim of the article is to carry out a retrospective analysis of events and a historical and technical summary of the main measures, problems, and consequences of the development of industrial production of rolling stock in Ukraine from 1991 to 2021 on the basis of a comprehensive analysis of sources and scientific literature. In the course of the scientific development of the proposed research, materials from mass-circulation newspapers, industry publications of railway transport, as well as technical studies of employees of manufacturing plants were used. It has been determined that during 1991–2008, the engineering and design team of HC “Luhanskteplovoz”, having a strong scientific and production potential, by order of the State Administration of Railway Transport – Ukrzaliznytsia – for the purpose of import substitution, designed and mastered the industrial production of innovative models of rolling stock for social purposes, namely diesel trains DEL-01 and DEL-02, as well as electric trains EPL2T and EPL9T to meet the needs of Ukrainian railways with high-tech equipment. It has been found that with the beginning of the economic and financial crisis of 2008 and a significant reduction in Ukrzaliznytsia's orders, the production of rolling stock at the facilities of HC “Luhanskteplovoz” was actually stopped, and the enterprise, privatized by a Russian investor, focused mainly on the production of locomotives. Instead, since 2012, the production of rolling stock on its own design platform has been mastered as part of the diversification of PJSC “Kriukiv Railway Car Building Works”. In the end, the historical experience of the formation*



and development of the Ukrainian research and production base of railway engineering needs to be properly understood in the context of a retrospective analysis of the industry's production activities to clarify the reasons for its inefficient development, as well as the determination of conceptual ways of harmonizing the domestic design and technological potential with the actual needs for updating the fleet of traction rolling stock of global transport operators. Further research into the history of the development of railway mechanical engineering in Ukraine requires clarification of the historical circumstances of the institutionalization of design bureaus of individual enterprises in the direction of scientific research activities.

Keywords: rolling stock; Luhansk (Voroshilovgrad) Diesel Locomotive Plant; Kriukiv Railway Car Building Works; railway engineering; Ukrainian railways; State holding company “Luhanskteplovoz”

Introduction.

Today, the situation with suburban transport in Ukraine has reached a critical state. According to the technical documentation, despite the overhaul and extension of the service life, the wear and tear of the suburban electric train fleet of JSC “Ukrzaliznytsia” amount to more than 87.5%, and diesel trains – 97.2%. In particular, on the railways of Ukraine, electrified with direct current, the electric trains of the Riga Wagon Building Plant of models EP1 and EP2, which have reached a 60-year period of intensive operation, and, accordingly, have exhausted all possible laid resources, are in operation. During the times of the USSR, specialized Ukrainian enterprises produced only freight cars and main-line diesel locomotives. In the absence of convertible currency for the purchase of a sufficient amount of equipment abroad, the management of Ukrzaliznytsia decided to combine imports with the organization of the production of rolling stock at existing capacities and to make an attempt to solve the problem on the basis of domestic enterprises of railway engineering (Moskalenko & Mukminova, 1996, p. 94).

Relevance of the topic.

The analysis of the history of the formation of the production activity of Ukrainian transport engineering enterprises is updated in the context of clarifying the causes of the systemic crisis of the industry in the early 2000s, searching for ways out of it for basic historical enterprises, determination of conceptual ways of harmonizing their design and technological potential with actual needs for updating the fleet of traction rolling stock of transport operators, based on the accumulated experience and the traditionally significant export potential of the industry.

Research and publication analysis.

For a long time, the prerequisites for the formation and the circumstances of the development of the industrial production of rolling stock in independent Ukraine did not find comprehensive coverage in the national historiography. The works by

A. Shternov (Shternov, 1967), G. Zhdanov (Zhdanov, 1981), V. Shcherbakov (Shcherbakov, 1998), V. Rybinets (Rybinets, 1996), Yu. Tsygankov-Serebryakov (Tsygankov-Serebryakov, 2006), G. Kudiyarova (Kudiyarova, 2019), and others are devoted to the study of production activities of domestic railway engineering enterprises. A retrospective analysis of the technical characteristics of domestic railway equipment, forecasting its design and technological development is presented in the works of V. Rakov (Rakov, 1990), G. Basov, S. Yatsko (Basov, 2000, 2001, 2004; Basov & Yatsko, 2005), O. Buyanov (Buyanov, 2005), E. Abramov (Abramov, 2015a), as well as a number of investigations by authors (Ruban, 2020a; Ruban, 2020b; Ruban & Fomin, 2020; Ruban & Ponomarenko, 2021). However, these studies have been focused mainly on the Soviet period of the history of enterprises, do not show the completeness of the outlined topic, and require the introduction of additional new sources into scientific circulation. The analysis of the history of the production activity of the transport engineering enterprises of Ukraine acquires its relevance against the background of the general reform of the domestic industry, the prospects of innovative post-war development, the need to renew the traction rolling stock, taking into account the historical experience of solving the specified issue.

The source base of the research has been made up of the legal acts of the Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine and branch Ministries, as well as the branch publications “Magistral”, “Ukrainian Technical Gazette”, “Economic News”, “October Horn” and “Vagonobudivnyk”.

Therefore, the subject of the study is the organization of the production of rolling stock at the industrial facilities of domestic enterprises during the years of independence. The chronological boundaries cover the period from the declaration of Ukraine's independence in 1991 to the beginning of Russia's open large-scale military aggression in February 2022, which is divided into three main stages: 1) the production monopoly of HC “Luhanskteplovoz” (1991–2008); 2) diversification of production of PJSC “Kriukiv Railway Car Building Works” (2008–2022); 3) focus on European manufacturers (since 2022).

The purpose of the article is to carry out a retrospective analysis of events and a historical and technical overview of the main measures, problems, and consequences of the development of the industrial production of rolling stock in Ukraine in 1991–2022 (at the facilities of HC “Luhanskteplovoz” and PJSC “Kriukiv Railway Car Building Works” – hereafter PJSC “KRCBW”), on the basis of a comprehensive analysis of sources and scientific literature, which involves solving the following research tasks: first, to find out the technical condition of the rolling stock of Ukrzaliznytsia in the 1990s; secondly, consider the prerequisites for construction and technical features of the MU produced by HC “Luhanskteplovoz”; thirdly, to determine the circumstances and reasons for the formation of the current monopoly position of PJSC “KRCBW” in the field of rolling stock production in Ukraine.

Research methods.

When writing the article, general scientific methods and principles of historical research have been used. The work is based on the principles of historicism, objectivity, continuity, multifactoriality, complexity, and pluralism. Historical-comparative, prosopographic, and problem-chronological methods (Fullerton, 2011) have been used in the study, which provided an opportunity to carry out a detailed analysis of the prerequisites, historical circumstances and development of the production of rolling stock in Ukraine in 1991–2022.

Results and discussion.

In the early 1990s, one of the main problems of the development of the logistical and technical base of rail transport in the CIS countries was the need to renew the rolling stock fleet. Until 1991, the only producer of rolling stock in the USSR was the Riga Wagon Building Plant (Latvia), some diesel trains were supplied by the countries of the socialist camp. In these conditions, already in the early 1990s, given the lack of convertible currency for the export of railway equipment, the search for ways to create own production of the specified products began.

The Russian government decided to urgently deploy the capacity for the production of electric commuter trains on the basis of the Demikhov Machine-Building Plant, the possibility of repurposing into the construction of additional trailer cars for electric trains was considered since the early 1980s. In parallel with this, the production of electric trains was started at the capacity of the Torzhotsk Car Building Plant (Abramov, 2015b, p. 344, 349, 350). In the fall of 1993, the first electric trains of both manufacturers were sent for testing to the experimental range of the Ministry of Communications of the Russian Federation, and the following year, the development of an electric train of its own design at the Novocherkassk Electric Locomotive Plant, as well as a diesel train of the Lyudinovsky Locomotive Plant, was started (Shcherbakov, 1998, p. 240; Abramov, 2015b, p. 248, 391).

In Ukraine, based on the mentioned circumstances, a scientific and technical cooperation section (STCS) was created at the State Administration of Railway Transport – Ukrzaliznytsia to coordinate the activities of manufacturers, scientific organizations, and railways, which included representatives of 6 railways of Ukraine, specialized departments of Ukrzaliznytsia, and factories – manufacturers of rolling stock and railway systems. The functions of STCS in the field of locomotive management were: development, testing, commissioning of traction rolling stock (TRS), modernization of existing TRS, changing the technology and rules of its operation, development of safety equipment systems on railways, etc. The first organizational meeting of STCS was held in Luhansk on August 19, 1992, during which the priority dates for the design and serial production stages of new equipment were agreed upon (Krayevoy, August 26, 1992; Lozovoy, August 26, 1992). In the conditions of the economic crisis of the 1990s and, accordingly, the decrease in demand for mainline diesel locomotives, the Central Design Bureau of Voroshilovgradteplovoz

was given the task of expanding the range of products in order to move away from single-purpose production with the maximum use of the available production capacities of the enterprise (Buyanov, 2005, p. 244).

Since the mid-1950s, the Luhansk Diesel Locomotive Plant not only specialized in the industrial production of mainline and shunting diesel locomotives with various types of transmission but also had successful experience in the development of gas turbo locomotives, conveyors for the transportation of oversized cargo with a carrying capacity of 160–320 tons (Shternov, 1967, pp. 113–117, 120). From 1976 to 1995, the Luhansk Diesel Locomotive Plant was called Voroshilovgradteplovoyz Production Association (in separate documents – PA “Luhanskteplovoyz”) (Zhdanov, 1981, p. 183, Rybinets, 1996, p. 340). The enormous experience of the staff of the Luhansk plant in the design and construction of experimental locomotives, as well as their research in experimental operational conditions, made an invaluable contribution to the world science of transport engineering. By the mid-1980s, PA “Voroshilovgradteplovoyz” produced 95% of main diesel locomotives in the USSR with a monthly schedule of 115–120 sections, and products were exported to the GDR, Bulgaria, Hungary, Czechoslovakia, Poland, the DPRK, Cuba, Syria, and Iraq (Zhdanov, 1981, p. 157; Tsygankov-Serebryakov, 2006, p. 323). The enterprise was of exceptional social importance, providing work for tens of thousands of Luhansk residents and supporting the social infrastructure of the city.

In July 1992, the Ministry of Machine-Building, Military-Industrial Complex and Conversion approved the “Railway Transport Development Program of Ukraine”, designed until 1998. During this time, PA “Voroshilovgradteplovoyz” was supposed to establish the production of 7 new types of rail cars, in particular electric and diesel trains, and at the enterprise itself, it was planned to create a testing ground for experimental rolling stock (Rybinets, 1996, p. 340). During the period from 1990 to 1999, the fleet of diesel trains in Ukrzaliznytsia drastically decreased – from 287 to 94 units, and electric trains – from 1512 to 1472 units (taking into account the almost complete development of the operational resource of this technique) (Fediushyn, 2001, pp. 7–8).

In 1992, the Central Design Bureau of PA “Voroshilovgradteplovoyz” began working on the drawings of the future diesel train, and already at the end of December 1993, at a meeting of the Technical and Economic Council of Ukrzaliznytsia in Luhansk, its preliminary project was discussed (Buyanov, 2005, p. 244). In accordance with the world practice of rolling stock development, an experimental diesel train with the electric transmission of alternating current and the use of asynchronous traction motors was developed, the release of which was planned to be established within 2 years (Moskalenko & Mukminova, 1996, p. 45).

On June 4, 1994, the Cabinet of Ministers of Ukraine adopted Resolution № 364 “On the organization of the production of diesel and electric train cars”, according to which the Ministry of Machine-Building, Military-Industrial Complex and Conversion was entrusted with the functions of coordinating work on the development of structures

of electric train cars, components for them, the creation of production facilities and the organization of their production, and PA “Voroshilovgradteplovoyz” was determined as the main enterprise-manufacturer of final products. In 1995, the amount of funding for research on the development of a diesel train amounted to 20 000 000 000 UAK (over 1 100 000 USD), preparation for production – 22 000 000 000 UAK (over 1 200 000 USD) in the prices of January 1, 1994, the number of capital investments for the creation of production facilities was also determined, which, however, given the economic situation at that time, was subject to annual indexation. According to the plan, 400 direct current electric train cars and 280 alternating current electric train cars were to be manufactured by 1998 inclusive. The total amount of funding for research and design works, as well as capital investments for the renewal of the Association’s production facilities, amounted to 1 482 400 000 000 UAK (over 84 708 000 USD) in 1994 prices (The Cabinet of Ministers of Ukraine (June 4, 1994) Resolution № 364 “On the Organization of the Production of Diesel and Electric Train Cars”)¹.

Luhansk Diesel Locomotive Plant in the conditions of market transformation of the economy of Ukraine.

As a result of the gradual disintegration of the single economic complex of PA “Voroshilovgradteplovoyz” into a number of independent enterprises, which led to the loss of controllability, unjustified diversification, and additional production costs, the prerequisites for deepening its crisis state were laid (Tsygankov-Serebryakov, 2006, pp. 265–266). On May 19, 1995, the State Holding Company “Luhanskteplovoyz” was created on the basis of PA “Voroshilovgradteplovoyz” by the decree of the President of Ukraine. On October 3, 1995, its state registration was carried out. On October 29, by order of the State Property Fund+ of Ukraine № 23 JSC “Voroshilovgradteplovoyz” was transformed into the State Holding Company “Luhanskteplovoyz”. At the proposal of the company's management, the State Property Fund decided to create a number of subsidiaries within it (Tsygankov-Serebryakov, 2006, p. 236).

In October 1996, the State Commission for Securities and the Stock Market registered information on the issue of the Company's shares. The State Property Fund of Ukraine has put up 24.9% of the Company's shares for a concessional sale, with all structural divisions of the Company and subsidiaries. At that time, the main problem, in addition to the decline in production, was excessively high costs for non-core assets of the social sphere. In particular, in 1996, not only the entire balance sheet profit of the Company was spent on their maintenance, but also partly the funds of product development and material incentive funds (Tsygankov-Serebryakov, 2006, p. 242, 245, 246).

¹ It should be noted that in 1994 alone, the inflation rate was more than 400%, and in general, by 1998, it is possible to state a complete depreciation of the funds laid down by this Resolution.

As of 1995, more than 40% of diesel trains were subject to decommissioning. On May 13, 1994, by Resolution № 308 of the Cabinet of Ministers of Ukraine “On State Support of Railway Transport in 1994” the state budget provided for the allocation of 1 000 000 000 000 UAK (over 57 000 000 USD) o Ukrzaliznytsia in the second half of 1994 for the acquisition and development of the production of rolling stock. As of 1995, more than 40% of diesel trains in Ukraine were subject to decommissioning, and during 1994–1995, in order to urgently replenish the fleet of rolling stock Ukrzaliznytsia purchased 1 DR1A diesel train, 6 ER2T electric trains and 5 ER9T electric trains from Latvia on a barter basis. However, already in 1996, suburban rolling stock was determined to be the last in priority in the sequence of payment of Ukrzaliznytsia payments (Moskalenko & Mukminova, 1996, p. 66, 94).

The development of a new range of products, in particular rolling stock, required the modernization of the existing production sites of HC “Luhanskteplovoz”. In particular, the production of special test stands for complex testing of pneumatic and electric systems. Mastering the production of electric trains required the construction of a test electrified section with a direct and alternating current contact network, as well as a traction substation. In order to ensure the production of rolling stock in the volumes expected for the needs of Ukrzaliznytsia, there was a need for capital investments of 10 000 000 UAH (over 5 600 000 USD). Ukrzaliznytsia was ready to allocate funds for new equipment in the form of a commodity loan with subsequent payment in the form of product supply for a period of 3 years. At the same time, the situation of HC “Luhanskteplovoz” was greatly complicated by the insufficient work of the company's economic management, since a number of contracts were executed with serious losses, as a result of which the company's financial condition became critical (Tsygankov-Serebryakov, 2006, p. 266).

In 1998, the first tender for the sale of shares in HC “Luhanskteplovoz” was announced. Resolution № 769 of the Cabinet of Ministers of Ukraine dated June 2, 1998, approved the State scientific and technical program “Development of rail rolling stock of social purpose for railway transport and urban economy” for 1997–2002. The production of the products envisaged by the program was supposed to save foreign exchange funds in the amount of 890 000 000 USD and create about 60,000 jobs with a payback period of 2.4 to 5.1 years for various types of products. As of 1999, the company's export volume increased 2.1 times and reached a share of 41.2% in the total production volume. Expenses decreased to 12 700 000 UAH (over 7 000 000 USD). However, the main cause of losses was not resolved – the costs of maintaining the state housing fund, the main assets of which were not included in the company's statutory fund, but were on its balance sheet. Thus, in 1998, 8 600 000 UAH were spent on its maintenance, including 6 600 000 UAH at the expense of balance sheet profit. The Company's subsidiaries had negative profitability (Tsygankov-Serebryakov, 2006, p. 240, 274).

In 2000, the first competition for the sale of 76% of the shares of HC “Luhanskteplovoz”, took place, in which the only participant and winner was

CJSC “AvtoKraz”. This fact was negatively perceived by the management of HC “Luhanskteplovoyz”, which was supported by the local authorities of the region, and even by the Ministry of Transport of Ukraine at that time. The Company's management demanded a new open tender, giving preference to Russian investors. In the end, the results of the competition were canceled by the State Property Fund, and a number of attempts to sell a controlling stake in HC “Luhanskteplovoyz” to a Ukrainian investor were unsuccessful (Tsygankov-Serebryakov, 2006, p. 314, 338). Only on July 19, 2006, the State Property Fund of Ukraine again allowed the sale of a controlling stake of HC “Luhanskteplovoyz”, and on March 23, 2007, it was sold to the Russian company “Transmashholding” for 58 000 000 USD (Pavlyuk, June 22, 2010).

Circumstances of creation and technical characteristics of rolling stock manufactured by HC “Luhanskteplovoyz”.

It was decided to time the release of the first DEL-01 diesel train with AC electric transmission and asynchronous traction motors presented in figure 1, consisting of 2 motor main and 2 trailer cars, to the 100th anniversary of the Luhansk plant in 1996 (Tsygankov-Serebryakov, 2006, p. 237).



Figure 1. DEL-01 diesel train on the territory of HC “Luhanskteplovoyz”, 1996. (Moskalenko & Mukminova, 1996).

During the preparation of the assembly of the diesel train, the team of HC “Luhanskteplovoyz” developed, manufactured, and implemented specialized equipment to ensure the temperature regimes of the technological process of painting, a new technology of cold oxidation in solutions that did not contain harmful substances was introduced, the process of processing wooden parts with a new flame retardant was introduced in the test and approval workshop, the production of original plastic and rubber products was mastered. Working drawings were also developed for an installation for automatic welding of the sidewalls of diesel train bogies, an installation for automatic arc spot welding along the perimeter of the frame decking sheets, and

automatic welding of the body roof (Tsygankov-Serebryakov, 2006, p. 240). On March 4, 1996, the coordination headquarters was established and the assembly of the main car of the diesel train began. The first section of the main carriage was to be assembled in March, and the second in April. However, this process was carried out in difficult conditions due to the absence of many nodes. As a result of late payment, the orders of the involved organizations of private ownership, created at the Company's production sites, were not provided (Torop, March 18, 1996). Nevertheless, in July 1996, the workers managed to conduct bench tests of nodes and complete the assembly of the diesel train, and already on August 3–4, 1996, the experimental model of the DEL-01-001 diesel train was presented at the exhibition “Railway Transport of Ukraine – 96” (Tsygankov-Serebryakov, 2006, p. 242).

The DEL-01 diesel train was designed for commuter transportation of passengers in regions with a temperate climate. The main component of a diesel train was 4 wagons (2 motor, 2 trailer). The control scheme provided the possibility of operating two articulated diesel trains from one control post. The transmission was electric, with asynchronous traction electric motors and frequency converters. The brake was electric, electro-pneumatic, and manual. The carriage of the motor car was non-pedestal with an individual drive of pairs of wheels. The suspension of the traction motor and traction reducer was support-frame. The torque was transmitted to the wheels through a hollow shaft and a rubber coupling. The two-stage spring suspension provided high smoothness of movement. The cars of the diesel train were equipped with the SA-3 auto clutch. The motor car had two, and the trailer had three external sliding doors on both sides. Passenger capacity – 416 people, including 72 in the motor car, and 136 in the trailer (Basov, 2004, pp. 108–110). For installation on the future diesel train by the Kharkiv Design Bureau of Engine Construction of the Plant named after V. Malyshev, on the basis of the six-cylinder tank engine, 6TD-1 of his own development in the mid-1970s, a 588DA diesel generator set with a capacity of 540 kW was created, which successfully passed factory and acceptance tests until 1996 (Budenny, 2001, p. 313, 364).

In the summer of 1996, the specialists of HC “Luhanskteplovoz” completed the development and began the production of an experimental batch of self-developed trailer cars in the amount of 8 units. On November 28, 1996, the running-in of the trailer car of the diesel train began on the Luhansk-Starobilsk section (Tsygankov-Serebryakov, 2006, p. 242). The frame elements of the cars were made of structural carbon or low-alloy steel; the cladding of the side walls, roof, and frame flooring were made of stainless steel. There were closed cylinder-type transition platforms between the cars, which ensured the safe passage of passengers from one car to another. The layout of the body is partially borrowed from Soviet electric trains: the main car had 2 on each side, and the intermediate car had 3 external sliding doors (Basov, 2004, pp. 177–192).

At the beginning of 1997, a training was conducted for chief specialists, heads of shops and services to implement the ISO 9000 international product quality assurance

standard. At the same time, the first launch was carried out and preparations for the tests of the DEL01-001 diesel train began (managers Yu. Kuzmenko, G. Glazunov, leading experts G. Pupinin, V. Myasnikov, G. Tikin). The general management of the activities was carried out by the head of the test center, deputy chief designer S. Hryshchenko (Tsygankov-Serebryakov, 2006, p. 244). On July 22–23, 1997, a meeting of the reception interdepartmental commission was held on the issue of diesel train tests. The commission reviewed the technical documentation and inspected the trailer wagons as part of suburban trains with a trial trip on the Luhansk-Northern – Transitna route. In some sections, the train reached a speed of 120 km/h. The commission approved the compliance of the wagons with the conditions for delivery and the possibility of operational tests on railways with passengers. At the same time, measures were outlined to improve the quality of wagons from the perspective of their serial production.

In the end, only at the end of 1998, with the participation of workers, designers, and chief specialists of the involved enterprises, in particular, NPO “Elektrotyazmash” (Kharkiv), NPO “Peretvoriuvach” (Zaporizhia) positive results were obtained from the settings and tests of the electric transmission on the first main section of the DEL-01 diesel train: it was possible to debug the system of work on two converters of traction asynchronous motors, there were prospects that in 1999 the DEL-01 diesel train would be able to start running tests. On July 29–31, 1999, the DEL-01 Luhansk diesel train was presented at the second International Exhibition “Railway Partners on the 1520 mm Track” (Kyiv) (Tsygankov-Serebryakov, 2006, p. 246, 257, 267). On September 5, 2000, HC “Luhanskteplovoz” was visited by the general director of Ukrzaliznytsia H. Kirpa on business, during which it was agreed to complete the testing of the prototype diesel train DEL-01 by November 1, 2000, and hand it over for operational tests to the Donetsk Railway (Tsygankov-Serebryakov, 2006, p. 279).

On October 24, 2000, HC “Luhanskteplovoz” presented the first Ukrainian-made eight-car direct current electric train EPL2T-001 presented in figure 2, which arrived at the Yasinuvata depot (Tsygankov-Serebryakov, 2006, p. 296). The electric train with a capacity of 960 kW is designed for the transportation of passengers on electrified sections of railways with a nominal voltage in the contact network of 3000 V direct current. And already on August 1, 2001, an eight-car suburban electric train of alternating current EPL9T was built at the enterprise. During the development of electric trains, the specialists of HC “Luhanskteplovoz” took as prototypes the electric trains of the Riga Wagon Building Plant EP2T and EP9T. The main difference between the Luhansk electric trains and similar models produced in Latvia and Russia was the increased length of the car to 25 m, as well as the division of the car into 2 cabins with entry and exit through vestibules (Basov, 2005, p. 123).

Electric trains EPL2T and EPL9T were designed for passenger transportation in regions with a temperate climate, in suburban traffic on electrified sections of railways (with a nominal voltage in the contact network of 3 kV direct current and 25 kV alternating current). The design speed was 130 km/h. The main component of electric

trains was 8 cars: 2 main, 4 motor, and 2 trailer. The length along the clutch axes was 8×25.275 mm. The number of seats: in the main carriage – 118, in the motor carriage – 118, and in the trailer carriage – 130. The voltage in the onboard network was 220 V (Basov, 2005, p. 123). During the construction of prototypes of electric trains, trolleys manufactured by the Russian company BAT “Zavod Transmash” (Tikhvin), were used, instead, as the production of electric motors was mastered by NPO “Elektrotyazmash” (Kharkiv), motor trolleys manufactured by HC “Luhanskteplovoz” (Basov, 2001, p. 61).



Figure 2. Electric train EPL9T-001. June 18, 2002 (Tsygankov-Serebryakov, 2006).

The carriage of the motor car is two-axle with double spring suspension: axel-box non-pedestal with friction vibration dampers and central cradle suspension with hydraulic vibration dampers. The traction drive had a combined suspension, the traction engine – support-frame, and the gearbox – support-axle. The supporting carriage of the main and trailing wagons was two-axle, non-pedestal with two-stage spring suspension. The body suspension was a spring-type “Flexi Coil”. The two-stage spring suspension ensured a smooth ride and passengers’ comfort. Electric train was equipped with electric, electric pneumatic, pneumatic, and manual brakes, as well as an automatic fire alarm system, an aerosol fire extinguishing system, and an on-board computer that could quickly notify the driver of a passenger stuck in the door and possible technical malfunctions (Basov, 2005, p. 134; Dumkevich, November 2, 2010).

For the first time, the idea of creating locomotive-haul diesel trains by using trailer cars of dismantled diesel trains of the DR1 series and sections of two-section diesel locomotives 2M62 in order to save money arose in the mid-1990s. Since the power of the two-section freight locomotive was redundant, instead of one of the sections, a modified main car of the DR1 diesel train was used with a control cabin and a passenger cabin in place of the engine compartment. In 1998, the Demikhovo Machine-Building

Plant (Russia) created DDB1 diesel trains, for which, according to a similar scheme, modernized sections of 2M62U diesel locomotives and trailer cars of its own production were used (Demikhovo Machinebuilding Plant. (2006). Diesel train DDB1 (DPSAA3)). At the same time, HC “Luhanskteplovoz” developed own suburban diesel trains of locomotive traction of permanent formation, which consisted of 97% of details of domestic manufacture. (Segodnya – Today. (July 31, 1998). Instead of an electric train – a commuter train).



Figure 3. Diesel trains of locomotive traction DPL2 at Luhansk station (Diesel train DPL2-002 at Lugansk station, January 5, 2014).

Luhansk permanent formation diesel trains, 1st type (with modernized diesel locomotive section 2M62, power 1471 kW, main and 2 trailer cars – DPL1) and 2nd type (with modernized diesel locomotive section 2TE116, power 3060 hp, main and 3 trailer cars – DPL2 presented in figure 3), intended for suburban transportation of passengers on non-electrified railway sections, were equipped with three intermediate cars and one main car. The brake was electro-pneumatic and manual. DTL1 (based on DPL1) and DTL2 (based on DPL2) diesel locomotive traction trains equipped with 3, and sometimes 4 trailer cars and 2 locomotive sections were also created (Basov, 2004, p. 100, 101). Diesel trains of the DPL1 and DTL1 series have arrived for operation at the Kolomyia and Kovel depots of the Lviv Railway, and the DPL2 – at the Rodakove depot of the Donetsk Railway (Tsygankov-Serebryakov, 2006, p. 272).

As of 2001, the level of wear and tear of rolling stock of all types of properties of Ukrzaliznytsia exceeded 57%, in particular, diesel trains – 82%, and electric trains – 72%. During the period 1991–2001, the average annual number of purchases of rolling stock was: electric trains – 9.1 units, and diesel trains – 0.6 units. (Fedyushin, 2001, pp. 7–8). In 2001, a total of 577 100 000 UAH (over 108 000 000 USD) was raised by Ukrzaliznytsia for the modernization of rolling stock, which was 2.3 times higher than similar costs in 2000. (Kirpa, 2004, p. 32). In 2001, the specific weight of electric trains in the product nomenclature of HC “Luhanskteplovoz” was 49.3%, diesel trains – 15.5%, and diesel locomotives – only 14.2%. During the year, the growth rate of production was 151.3%, and the volume of manufactured products – 89 500 000 UAH

(over 16 700 000 USD) (Tsygankov-Serebryakov, 2006, p. 300–301). According to the testimony of the General Director of Ukrzaliznytsia H. Kirpa, the preparation and organization of the production of rolling stock at that time allowed to ensure their production of up to 200 units per year (Kirpa, 2004, p. 34).

However, already in the middle of 2002, the volume of financing of Ukrzaliznytsia's orders for the production of rolling stock was significantly reduced due to both the drop in transit of rail transport and the simultaneous participation of Ukrzaliznytsia in higher priority investment projects. In addition, in 2002, the management of the Donetsk Railway unexpectedly ordered 4 ED2T trailer head cars from the Russian Demikhov Machine-Building Plant (Abramov, 2015b, p. 350). HC "Luhanskteplovoz" felt an acute shortage of its own working capital. Attracting investments and bank loans was unrealistic at that time. In connection with the decrease in the amount of financing from Ukrzaliznytsia, the company planned to increase the volume of orders for a specific type of product – diesel locomotives, as well as to resume the production of trams (Tsygankov-Serebryakov, 2006, p. 306 – 307).

Meanwhile, the preliminary test results of the DEL-01 diesel train showed that the implemented technical solutions basically confirmed the correctness of the selected design parameters. In 2000, work was carried out on its improvement: revised design documentation of the main car, metal constructions of the body, interior, salon, chassis, developed drawings of bodies, the interior lining of the salon taking into account the updated ergonomic shape of the cabin, introduction of block windows and hidden fastening of the cabin. Based on the results of the tests, the control systems and equipment were updated and modernized. In 2001, on the basis of the DEL-01 diesel train, the development of the design documentation of the three-car DEL-02 diesel train with a new design of cars and underbody location of the POWER RACK power module (diesel generator set) manufactured by the German company MTU Aero Engines was started (Tsygankov-Serebryakov, 2006, p. 282).

The design of the motor car of the DEL-02 diesel train was determined by the futuristic cab of the driver, designed by the RDE "Rost" presented in figure 4. The main component of a diesel train was 3 cars (2 motor, 1 trailer). The control scheme provided the possibility of operating 2 articulated diesel trains from one control post. The number of seats was 336, including 100 in the motor car, and 136 – in the trailer car. The hourly power of the main diesel engines was 2×748 hp. Design speed – 130 km/h. The transmission of the diesel train was electric of alternating current, which consists of a traction synchronous generator, a rectifier-inverter frequency converter, and 2 asynchronous traction electric motors of the AD-906 type. Traction motors were powered by autonomous voltage inverters. The microprocessor control unit ensured the optimal operation of the power transmission in various driving modes. The connection of the microprocessor unit with the control panel, the diesel engine, and the main transmission elements was digital. The diesel engine of the train was V-shaped twelve-cylinder four-stroke with gas turbine inflation and liquid cooling. The power of each of the 2 diesel engines was 550 kW (Basov, 2004, p. 134).

In December 2002, after acceptance tests, the DEL-01 diesel train began running tests at the Rodakove depot. On December 18, at a joint meeting with representatives of Ukrzaliznytsia, a decision was made to build a new DEL-02 diesel train, and on July 29, 2003, its ceremonial presentation took place (Buyanov, 2005, p. 249). In October 2004, HC “Luhanskteplovoz” built an experimental motor car EPL2T with trolleys designed for a speed of up to 160 km/h. There were plans for equipping future electric trains with these trolleys and converting all existing electric trains (Basov, 2005, p. 146; Tsygankov-Serebryakov, 2006, p. 310, 312, 317, 324). Further production of rolling stock was accompanied by an increase in the share of equipment of Ukrainian enterprises, hence the high degree of localization of production. HC “Luhanskteplovoz” also carried out work on the creation and mastery of the production of motor and non-motor rolling stock bogies with radial wheels, a design speed of 160–200 km/h and an axial load of 19 tons (Kirpa, 2004, p. 35).



Figure 4. Diesel train DEL-02 with managers of HC “Luhanskteplovoz” (DEL-02, 2002).

In December 2004, motor-car rolling stock produced by HC “Luhanskteplovoz” was awarded the State Prize of Ukraine in the field of science and technology “*For the creation, mastery of production and introduction of domestic motor-car rolling stock of social purpose for suburban passenger transportation*” (Stohniy, 2009, p. 200).

In 2006, the EPL2T-017 electric train was first equipped with a new plastic streamlined cabin, and in 2008, the first EPL9T-015 electric train was also equipped with a streamlined cabin. In 2008, the production facilities of HC “Luhanskteplovoz” allowed to ensure the production of up to 140 cars of suburban trains per month. In 2008, the plant team produced 56 cars of direct and alternating current suburban

electric trains. Together with the Donetsk Railway, the team of HC «Luhanskteplovoz» carried out a large amount of work on the proofing of the design of the crew and running parts of electric trains, which was foreseen by the decision of the interdepartmental commission. An improved trolley of its own design was developed, tested, and put into production. According to the results of 11 months of work in 2008, the volume of production amounted to 1 000 000 000 UAH which became a record economic indicator for 17 years. The increase in production rates was almost 200% (Spektor, February 5, 2009). However, soon the global economic crisis of 2008 significantly complicated the Company's situation. In particular, the construction of the EPL2T-036 electric train was interrupted already in November 2008 (all 8 cars were built entirely of metal, with the exception of the trolleys) and at the time of publication of the article, for 14 years, the unfinished electric train has been standing in one of the non-working workshops.

In 2009, the financial plan of “Ukrzaliznytsia” provided for the purchase of 4 electric trains from HC “Luhanskteplovoz”. At that time, work on restructuring and optimization of the number of employees was carried out on the basis of the order of Ukrzaliznytsia (Osobova, April 28, 2009). At the beginning of November 2009, the results of the auction for the privatization of the Luhansk plant were canceled by the decision of the commercial court of the Luhansk region. However, already on June 15, 2010, CJSC “Transmashholding” repurchased the controlling stake of HC “Luhanskteplovoz” for 51 000 000 USD (Pavlyuk, June 22, 2010).

Perspective developments of high-speed rolling stock.

In October 2008, the Ministry of Transport of Ukraine approved the “Comprehensive program for the renewal of railway rolling stock of Ukraine for 2008–2020”. The program determined that in order to organize high-speed traffic by 2020, it is necessary to replenish the railway fleet of Ukraine with interregional electric trains at a speed of 160 km/h with 40 units, two-system electric trains with a tilting body at a speed of 200–220 km/h – 17 units. Planning the creation of high-speed electric trains, the management of HC “Luhanskteplovoz” held negotiations with the Siemens company. The main technical issues were resolved, and preliminary volumes of deliveries and prices for equipment sets were agreed upon. In addition, in August 2007, protocols were signed between HC “Luhanskteplovoz” and Ukrzaliznytsia for the creation, manufacture and purchase of 58 direct current electric trains with an asynchronous drive with a design speed of 160 km/h EPL5T and 85 modernized electric trains of interregional direct and alternating current connections EPL2TM and EPL9TM (Spektor, February 1, 2011).

On the eve of the 2012 European Football Championship, the Cabinet of Ministers of Ukraine decided on the purchase of high-speed rolling stock. HC “Luhanskteplovoz” proposed to create new models of high-speed interregional electric trains with a speed of over 200 km/h. 3 The deputy technical director of HC “Luhanskteplovoz” N. Naysh noted that the production of electric trains at a speed

of 160–200 km/h at the enterprise was possible if the experience of one of the international foreign companies was involved in the creation of a joint venture with the gradual localization of production in Ukraine (Spektor, February 1, 2011). However, during the visit to South Korea, an agreement was signed on the purchase by Ukrzaliznytsia of 10 Hyundai Rotem HRCS2 interregional electric trains and 4 diesel trains in the amount of more than 1 billion USD (Spektor & Masyuchenko, August 4, 2009).

Despite this, the specialists of HC “Luhanskteplovoy” continued to search for technical solutions that would allow the introduction of high-speed passenger transportation with minimal costs. The project of the EPL20T interregional electric train with a maximum operating speed of 140 km/h was developed. Calculations showed that with a race length of more than 18 km, the technical speed of such a train will be at least 120 km/h. In addition, at the current stage of track reconstruction under the current restrictions, it would not be possible to fully utilize the high-speed qualities of trains designed for a maximum speed of 160 km/h. The first samples of the EPL20T electric train could be released within a year after the conclusion of the supply contract. With an eight-car design, the electric train had a capacity of about 580 passengers, and its cost did not exceed UAH 95 million. (less than 9 000 000 euros). For a price comparison, the cost of the Hyundai Rotem HRCS2 electric train is 30 000 000 euros with a capacity of 580 passengers (Spektor, February 1, 2011). In the spring of 2010, Ukrzaliznytsia had plans to order the construction of two-system high-speed interregional trains with an asynchronous traction drive at the facilities of HC “Luhanskteplovoy”. According to preliminary data, it was supposed to be an all-wheel drive train without locomotive traction with improved dynamics and the highest level of comfort (Transport, March 30, 2010). In 2011, HC “Luhanskteplovoy” took part in a tender for the supply of 2 EPL20T interregional electric trains with a speed of 140 km/h (Yurova & Spektor, May 31, 2011). Due to the lack of funding from Ukrzaliznytsia, all work in this direction was canceled.

At the same time, before the 2012 European Football Championship, the team of PJSC “Kriukiv Railway Car Building Works” developed its own project of a high-speed two-system electric train with an estimated speed of 200–220 km/h. For comparison: as early as 1991, a rental company was created at the facilities of the Kremenchuk production association of wagon-building, and already on December 22, 1993, its property was privatized by a newly created joint-stock company (Kudiyarova, 2019, p. 21; The Cabinet of Ministers of Ukraine (December 17, 1994).

Order № 1120-r “On granting permission for the privatization of the property of the leased enterprise “Kriukiv Railway Car Building Works”). On October 11, 1994, by a resolution of the CMU, JSC “Kriukiv Railway Car Building Works” (hereinafter – KRCBW) was designated as the main developer of design documentation and a manufacturer of new competitive passenger cars of innovative design for Ukrzaliznytsia (The Cabinet of Ministers of Ukraine (October 11, 1994) Resolution № 703 “On the organization of the production of passenger cars”). In the early 2000s,

JSC “KRCBW” gained practical experience in the creation of subway cars, innovative freight cars, as well as locomotive-hauled passenger cars with a speed of 160 km/h (Kirpa, 2004, p. 178; Kudiyarova, 2019, p. 58). Until then, the Company had managed to stabilize its financial position due to the expansion of the product range, update the fixed assets with the most modern equipment, preserve the design and technological potential, having mastered the industrial production of new types of rail rolling stock (Danylyshyn, 2007, p. 187).



Figure 5. Electric train EKr1-001 “Tarpan”, 2012 (Kudiyarova, 2019).

Since 2012, PJSC “KRCBW” on its own initiative and with its own funds has started designing a new family of suburban, regional and interregional railcar trains of a new generation, in particular diesel trains, electric trains of various current systems with bodies of a similar design. The total amount of own investments in the project of creating a two-system high-speed interregional electric train with asynchronous traction electric motors amounted to more than 400 000 000 UAH (50 000 000 USD), and already at the beginning of 2012, the first 2 samples of the experimental electric train EKr1 (Kryukiv electric train, 1st type), which was named “Tarpan” presented in figure 5, were built and tested at PJSC “KRCBW” (Kudiyarova, 2019, pp. 290–291).

Electric train EKr1 consisted of 7 trailer and 2 main motor cars. Passenger capacity – 612 people. The design speed was 200 km/h. Brake – electric, electro-pneumatic, pneumatic (Kudiyarova, 2019, p. 290–291). The cars of the electric train were equipped with cradleless trolleys with a central pneumatic suspension of modifications 68-7072 (main car) and 69-7049 (intermediate car). The electrical equipment of these cars had a backup power supply system in case of failure of the main static converter. For the first time in Ukraine, the main cars of an electric train were also equipped with an energy absorption system in frontal collisions up to 2 MJ. The price of the EKr1 electric train was 20 850 000 USD). However, the company was unable to fully certify its train in time before the start of the championship, and only

on January 31, 2013, the interdepartmental commission put it into operation with a maximum speed of 160 km/h (Kudiyarova, 2019, p. 337).

The creation of the DPKr2 diesel train began as a result of the victory of PJSC “KRCBW” in the tender announced by Kazakhstan Railways. During the development, the designers also took into account the regulatory technical requirements in force in Ukraine. In the summer of 2014, a prototype of the DPKr2-001 diesel train presented in figure 6, was assembled and was named “Obriy”. The DPKr2 diesel train was intended for the transportation of passengers in suburban and interregional traffic on non-electrified sections of railways, equipped with both high and low platforms. The design speed of the DPKr2 diesel train was 154 km/h. The mask of the main car contained a “crash system”, which, in the event of a head-on collision, absorbed the main impact. The carriages are equipped with lifting equipment and places for people with disabilities. The undercarriage of each car was equipped with 2 two-axle bogies with pneumatic springs manufactured by PJSC “KRCBW”, 1 drive (model 68-7085), and one non-drive (model 68-7090). The trolleys were equipped with an electronic system of sensors: an anti-lock device, monitoring the heating of the axle assemblies, as well as speed. For more effective coupling of the train with the rails on the carts, a sand supply system was installed in the area of contact between the wheel and the rail. Each car was equipped with a power unit located in the undercarriage space. A diesel engine with a capacity of 390 kW drives a hydraulic transmission of the hydrodynamic type, which drives the wheel pairs, as well as an electric generator of its own needs of three-phase alternating current with a voltage of 380 V and a capacity of 70 kVA, which serves to power all the equipment of the car. The total number of seats in a three-car train was 283 ordinary and 6 folding, and the maximum capacity of the train including standing places was 637 people. A feature of this diesel train is the possibility of its operation at temperatures from -50 to $+50$ degrees (Kudiyarova, 2019, p. 315–317).



Figure 6. Diesel train DPKr2-001 on the Lviv Railway (Kudiyarova, 2019).

In 2014, PJSC “KRCBW” also developed technical tasks for suburban electric trains of AC EKr3 (Kryukiv electric train, 3rd type) and direct current EKr4 (Kryukiv

electric train, 4th type). Localization of rolling stock production of PJSC “KRCBW” amounted to 70%, which made it possible to create more than 5,000 new jobs PJSK “Kriukiv Railway Car Building Works” (February 1, 2019). KRCBW is ready to participate in the reform of suburban railway communication as a partner). In 2014, as a result of Russia's aggression and its declaration of the organization “Luhansk People's Republic”, Ukraine completely lost the HC “Luhanskteplovoz”. Consequently, competition among domestic manufacturers of railway rolling stock has ceased since 2015. The only manufacturer of this type of product remained PJSC «KRCBW». In the spring of 2017, JSC “Ukrzaliznytsia” announced another tender for the supply of 6 three-car regional diesel trains for the amount of 1,062,000,000 UAH (over 41,000,000 USD), in which PJSC “KRCBW”, the Polish company Pesa and LLC “Kharkiv Wagon Building Plant” participated. However, soon JSC “Ukrzaliznytsia” canceled the bidding, rejecting all submitted applications due to the inconsistency of the tender documentation (Center for Transport Strategies (November 17, 2017). JSC “Ukrzaliznytsia” again announced a tender for the purchase of 6 regional diesel trains).

In the end, following the results of the victory in the next tender, PJSC ‘KRCBW’ developed and manufactured a regional diesel train DPKr3 (Kryukiv Diesel Train, 3rd type) presented in figure 7, with a capacity of 170 seats and a maximum speed of 140 km/h. Its concept was based on the design of the cars of the DPKr2 diesel train, taking into account the experience of its operation, the manufacturer made a number of changes that were the most acceptable for the rolling stock operating in the suburban service of JSC “Ukrzaliznytsia”. The diesel train consisted of 3 cars – intermediate non-motor 63-7084A, main motor 63-7083A and main motor 63-7083A-01, equipped for transporting passengers in wheelchairs. The motor cars are equipped with power plants with a capacity of 588 kW, which in total will not be inferior in power to 3 units installed in each of the DPKr2 cars. A modular diesel-hydraulic power plant Voith RailPack 600 DH produced by the company “Voith” (Germany) is installed on the main motor cars in the underbody space. The intermediate, non-motor car was powered by 2 power plant generators located on the main cars. One of the main cars had 58 second-class seats, the other main car had 51 second-class seats, this car had an enlarged sanitary module for passengers with disabilities, and there was room for wheelchairs. In the intermediate carriage, 61 first-class seats and a sanitary module were provided. The cost of one DPKr3 diesel train was 176 970 000 UAH (about 6 300 000 USD) (PJSK “Kriukiv Railway Car Building Works” (August 20, 2019.) KRCBW presents the DPKr-3 regional diesel train).

Despite the successful construction as part of the tender of the first four samples of the DPKr3 diesel train and the possibility of production of electric trains by PJSC “KRCBW”, JSC “Ukrzaliznytsia” persistently attempts to hold a tender with the involvement of the Swiss company Stadler Rail AG or the supply of 80 electric trains with localization of production in Ukraine in the amount of 31 462 000,000 UAH (over 1 153 300 000 USD) (International exhibition Rail Expo (2022). Ukrzaliznytsia

cancels the tender for the purchase of electric trains). However, with the start of military operations on the territory of Ukraine on February 24, 2022, the prospects for this cooperation remain uncertain.



Figure 7. Diesel train DPKr3-001, 2019 (PJSC “Kriukiv Railway Car Building Works” (August 20, 2019.) KRCBW presents the DPKr-3 regional diesel train).

Conclusions.

So, analyzing the dynamics of the development process of the industrial production of rolling stock, its following stages can be distinguished. The first stage was associated with the establishment of a production monopoly of HC “Luhanskteplovoyz” (1991–2008). For a long time OJSC “Voroshilovgradteplovoyz”, having a powerful research and production potential, carried out the development and created unique projects of railway equipment, which were exported to many countries of the world. In the early 1990s, in the absence of convertible currency in the country for the import of rolling stock, the Association had the opportunity to carry out conversion and diversification of production against the background of a gradual decrease in demand for main-line diesel locomotives and an aggravation of the economic crisis. In the conditions of falling demand for diesel locomotives, HC “Luhanskteplovoyz” was forced to work in a research and experimental mode, when serial production – the main source of profit was practically stopped, and the pace of development of new equipment did not allow to compensate objective costs. According to the technical director of HC “Luhanskteplovoyz” G. Basov (Basov, Naysh, Mishchenko, Gundar, & Lozovoy, 2002) the company acted in fact as a research and production association, which carried out the entire cycle of product creation from design to implementation into serial production without the presence of specialized research institutes, design bureaus and a minimal scientific department in the field of production of motor-carriage rolling stock of social recognition (Basov, 2000, p. 18). In addition, the parasitic approaches of the state monopoly were manifested during economic activity. The calculation made for the development of the production of new equipment exclusively on the budgetary basis of financing turned out to be wrong in the new conditions. The company's management

failed to refocus on resources that could be provided by customers and consumers of products. The preparation of new types of equipment urgently needed own funds, which were not enough for such a scale of investments (Tsygankov-Serebryakov, 2006, p. 266).

In order to implement a number of state programs in the period from 1996 to 2003, HC “Luhanskteplovoz” mastered the industrial production of rolling stock and created: a unified passenger trailer car for suburban transportation, DPL1 locomotive traction diesel train, DPL2 locomotive traction diesel train, DEL-01 and DEL-02 asynchronous traction diesel trains, EPL2T direct current and EPL9T alternating current electric trains. Designers of HC “Luhanskteplovoz” also started the development of promising high-speed electric trains of interregional connection EPL5T and EPL20T. However, in view of the protracted process of the corporatization of the enterprise, the low level of the company's management culture during the period of market transformation of the Ukrainian economy, as well as the uncertainty of further orders and the solvency of Ukrzaliznytsia HC “Luhanskteplovoz” was forced to curtail the diversification process and focus on the production of locomotives and their components under the contracts of the Russian Federation.

In parallel with this, the development of own projects of new generation rolling stock was carried out by the designers of PJSC “Kriukiv Railway Car Building Works” with the diversification of its production and the related second stage of development of MU in Ukraine. Unlike HC “Luhanskteplovoz”, having a more effective management model due to its own investments, PJSC “KRCBW” presented successful prototypes of the high-speed interregional electric train EKr1 “Tarpan”, DPKr2 and DPKr3, which technologically and cost-wise surpassed the products of HC “Luhanskteplovoz” and are now successfully operated on the tracks of JSC “Ukrzaliznytsia”. Today, PJSC “KRCBW”, having its own powerful design and technological basis and production facilities, has actually occupied a monopoly position as a supplier of rolling stock for JSC “Ukrzaliznytsia” among domestic manufacturers of railway equipment. The third stage of the development of MU in Ukraine is connected with persistent attempts of JSC “Ukrzaliznytsia” to advance the monopoly of PJSC “KRCBW” by localizing the production of one of the European manufacturers on the territory of our country.

The principal conclusion we reached during the research is that the main reason for the financial problems of HC “Luhanskteplovoz” was the lack of clear business processes in subsidiary units and excessive management costs for long-term maintenance of non-core social infrastructure, which is generally unthinkable in a market economy and healthy economic competition. This management model was not only a mistake of the company, but in general, it was a consequence of the social state policy of those years. If the Eastern European countries during the reforms of the 1990s resorted to strict restrictions on social spending, then Ukraine, like most of the CIS countries, continued to live with populism, as a result, having received an uncompetitive industry of the state sector of the economy. On the other hand, the

success of the diversification of PJSC “KRCBW”, which, moreover, was connected with the development of highly knowledge-intensive products practically from scratch, is due to rapid corporatization and more effective management of the company, which together made it possible to attract large investments and carry out the large-scale renewal of production assets and increase energy saving of production as a whole. Our next studies will be dedicated to proving this hypothesis.

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Освоєння та розвиток промислового виробництва моторвагонного рухомого складу в Україні (1991–2022)

Анотація. У статті здійснено спробу дослідити історичні обставини освоєння та розвитку промислового виробництва моторвагонного рухомого складу в Україні 1991–2021 рр. Мета статті – здійснити ретроспективний аналіз подій та історико-технічне узагальнення основних заходів, проблем та наслідків освоєння промислового виробництва моторвагонного рухомого складу

в Україні 1991–2021 рр. на підставі комплексного аналізу джерел та наукової літератури. В ході наукової розробки запропонованої розвідки були використані матеріали багатотиражних газет, галузевих видань залізничного транспорту, а також технічні дослідження працівників заводів-виробників. Визначено, що протягом 1991–2008-х рр. інженерно-конструкторський колектив ХК “Луганськтепловоз”, маючи потужний науково-виробничий потенціал, на замовлення Державної адміністрації залізничного транспорту – Укрзалізниці – з метою імпортозаміщення здійснив конструювання й освоїв промислове виробництво новаторських зразків моторвагонного рухомого складу соціального призначення, а саме дизель-поїздів ДЕЛ-01 та ДЕЛ-02, а також електропоїздів ЕПЛ2Т та ЕПЛ9Т для забезпечення потреб українських залізниць високотехнологічною технікою. З’ясовано, що з початком економічної фінансової кризи 2008 р. та суттєвим скороченням замовлень Укрзалізниці виробництво моторвагонного рухомого складу на потужностях ХК “Луганськтепловоз” було фактично припинене, а приватизоване російським інвестором підприємство зосередилось переважно на виробництві локомотивів. Натомість з 2012 р. виробництво моторвагонного рухомого складу на власній конструкторській платформі було освоєно в рамках диверсифікації ПАТ “Крюківський вагонобудівний завод”. Зрештою, історичний досвід становлення та розвитку української науково-виробничої бази залізничного машинобудування потребує свого належного осмислення в контексті здійснення ретроспективного аналізу виробничої діяльності галузі щодо з’ясування причин її неефективного розвитку, а також визначення концептуальних шляхів узгодження вітчизняного конструкторсько-технологічного потенціалу з актуальними потребами в оновленні парку тягового рухомого складу світових транспортних операторів. Подальше дослідження історії розвитку залізничного машинобудування в Україні потребує з’ясування історичних обставин інституалізації конструкторських бюро окремих підприємств у напрямку здійснення науково-дослідної діяльності.

Ключові слова: моторвагонний рухомий склад; Луганський (Ворошиловградський) тепловозобудівний завод; Крюківський вагонобудівний завод; залізничне машинобудування; українські залізниці; Державна холдингова компанія “Луганськтепловоз”

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Background of creation, further development, and establishment of Kharkiv Locomotive Plant

***Abstract.** The late XIX century was marked by the rise of industry in the Russian Empire. This period was characterized by shifting the core of industrial development from the Ural region to the south of the country, associated with the development of abundant coal deposits in Ukraine, and accompanied by extensive railroad construction in the central and southern parts of the Russian Empire. This aspect spurred the expansion of machine-building industries under the protectionist economic policy of the Russian Empire's government toward Russian enterprises. It was aimed at shielding them from the influence of foreign competitors. In the early 1870s, Kharkiv started growing rapidly as a major industrial hub in the south of the Russian Empire.*



The railroad offered an opportunity for the delivery of the most advanced equipment and technology, something that foreign companies never failed to take advantage of. In the 1890s, transport machinery gained significant development. Since 1891, the monopoly on steam locomotive construction in the Russian Empire, which had been concentrated in the 1880s at the Kolomna Locomotive Plant alone, was disrupted. In the mid-1890s, steam locomotive construction was deployed at eight major machine-building enterprises of the Russian Empire. This article is intended to provide a thorough analysis of the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant. It offers an overview of different stages throughout the history of the Kharkiv Locomotive Plant. This article discusses the conditions and prerequisites for choosing the location of the plant; considers the stage of the establishment (foundation) of the plant; examines the stage of plant construction and equipping it with technological facilities in detail; analyzes the development and establishment of the plant between 1897 and 1914. A brief analysis of locomotive designs produced by the Kharkiv Locomotive Plant from 1897 to 1914 has been made. The article shows the significance of Consultative Congresses of Traction Engineers for the development of railway machinery both at Kharkiv Locomotive Plant and for the entire railway industry.

Keywords: *steam locomotive; history of steam locomotive construction; Kharkiv; steam locomotive of the “normal type”; “O” class steam locomotives; “Shch” class steam locomotive*

Introduction.

December 2022 marks the 125th anniversary since the first steam locomotives were manufactured in Ukraine at the Kharkiv Locomotive Plant (hereinafter referred to as KhLP).

Many aspects concerning the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant are considered by many authors (Baker, 2006; Diakova, 2018; Gatrell, 1994; Grant, 1999; Jacolin & Roth, 2016; Kryvokon, 2014; Le Fleming & Price, 1960; Radoguz, Zaitsev, Gutnyk, & Tverytnykova, 2019; Redka, Islamova, Borzilo, & Shelukhina, 2020; Sorochynska, 2009, 2013, 2015a, 2015b; Yeremenko & Kroytor, 2020; Zhaloba, 2016).

The articles by Sorochynska (2009, 2013, 2015a, 2015b) briefly discuss the contribution of Kharkiv Locomotive Plant to the development of the locomotive industry in Ukraine. The main types of locomotives that were built at Kharkiv Locomotive Plant are presented. The importance of the origin of the steam locomotive industry in Ukraine is determined. However, Sorochynska's papers focus on the study of the scientists and workers of the plant (O. S. Rayevsky, M. L. Shchukin, Yu. V. Lomonosov, and others), and the consideration of their contribution to the steam locomotive industry as a whole, rather than the background of the creation and development of the Kharkiv Locomotive Plant.

The scientific work carried out by Annenkova (2014) investigates the arrangement of machine tool production at the Kharkiv Locomotive Plant from its foundation to nationalization by the Soviet authorities in 1919. It was found that there was a deficit of such equipment in the country at the time of the introduction of machine tools at the KhLP, which contributed to the improvement of this direction.

An article by Diakova (2018) highlights the welfare of workers at the Kharkiv Locomotive Plant. It is noted that social infrastructure for the employees of the enterprise was initially created during the construction of the plant.

Kryvokon (2014, 2021) covered the stages of creation and the functioning of the Kharkiv Locomotive Plant in more detail. However, his articles are focused on the study of the background and peculiarities of the arrangement of the tractor industry in Ukraine. In this context, these articles describe the establishment of Kharkiv Locomotive Plant from its foundation to its transition to tractor production.

Thus, a thorough analysis of the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant is still an urgent task for researchers of science and technology development in Ukraine. This article is aimed at solving this problem.

Research methods

During the preparation of the article, chronological, comparative methods of historical knowledge, classification, and systematization of historical sources and bibliographic material were used (Pylypchuk, O. Ya., Strelko, & Pylypchuk, O. O., 2021; Strelko, 2021; Strelko, Berdnychenko, Pylypchuk, Pylypchuk, Sorochynska, & Horban, 2021; Strelko, & Pylypchuk, 2021a). The use of these methods and approaches to scientific research allowed to retrace the of the creation, further development, and establishment of the Kharkiv Locomotive Plant 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.

Conditions and prerequisites for selecting the location of the plant.

The late XIX century was marked by the rise of industry in the Russian Empire. This period was characterized by shifting the core of industrial development from the Ural region to the south of the country, associated with the development of abundant coal deposits in Ukraine, and accompanied by extensive railroad construction in the central and southern parts of the Russian Empire. This aspect spurred the expansion of machine-building industries under the protectionist economic policy of the Russian Empire's government toward Russian enterprises. It was aimed at shielding them from the influence of foreign competitors.

In the second half of the nineteenth century the Russian railways began to buy their locomotives and other equipment from domestic producers (Westwood, 1982).. However, this break from foreign suppliers was accompanied by a continuing interchange of experience between Russian railway engineers and their western counterparts. In 1892 the young International Railway Congress Association held its second conference in Moscow, presided over by the Belgian locomotive designer Belpaire. Belpaire, and French engineers, helped with the design of certain Russian steam locomotives. A little earlier, the Russian railway engineer Borodin had presented a paper to the Institute of Mechanical Engineers in London. In tsarist Russia there was hardly a national school of locomotive design as there was in Britain, America, or France. Both in external appearance and in the chosen technical solutions, Russian locomotives were akin to those of Central Europe. But in certain fields Russian locomotive engineers and researchers had not been content to follow others. Especially in the methodical testing of locomotives, and the adaptation of locomotives to burn unusual fuels, enough work had been done to attract the interest of foreign railways.

Kharkiv was chosen as a location for constructing a machine-building plant because of several favorable conditions: 1. Being a hub for the Kursk-Kharkiv-Sevastopol, Kharkiv-Mykolaiv, and Southeastern Railways, which provide transport links between the raw material base, the production site, and the country's industrial centers; 2. Proximity of the production site to the Donetsk coal and Kryvyi Rih iron-ore basins; 3. Opportunity to engage skilled workers from medium and small city enterprises in production; 4. Availability of the University and the Technological Institute for training engineers in the city; 5. Possibility of allocating a large area on the eastern outskirts of the city for construction, located close to the Balashovska freight station (today, the Kharkiv-Balashivsky railway station) of the Kharkiv-Balashivsky line of Southeastern Railways Company, commissioned in 1895.

The stage of the establishment (foundation) of the Kharkiv Locomotive Plant.

In the early 1870s, Kharkiv started growing rapidly as a major industrial hub in the south of the Russian Empire. The railroad offered an opportunity for the delivery of the most advanced equipment and technology, something that foreign companies never failed to take advantage of. Melgoze, Trepke, Helferich, von Ditmar, and Bergenheim built their plants in Kharkiv (Annenkova, 2014; Sorochnytska, 2015b). The late XIX century witnessed the emergence of Kharkiv as the capital of agricultural machinery and equipment production. The leading position was assigned to the largest plant of Helferich-Sade.

In the 1890s, transport machinery gained significant development. Since 1891, the monopoly on steam locomotive construction in the Russian Empire, which had been concentrated in the 1880s at the Kolomna Locomotive Works alone, was disrupted. In the mid-1890s, steam locomotive construction was deployed at eight

major machine-building enterprises of the Russian Empire, of which two plants (Kharkiv and Luhansk) emerged as specialized steam locomotive enterprises.

Kharkiv Locomotive Plant was founded by the Russian Locomotive and Mechanical Joint Stock Company (RLM JSC). Two board seats of the RLM JSC were given to Stéphane and Philippe Bouet, the owners of the machine-building plants in Paris. Philippe Bouet, as one of the co-founders of the RLM JSC, secured an agreement with the Administration of Russian State Railways, providing for 480 steam locomotives as the first order, as well as the right to establish a plant in the Russian Empire to manufacture steam locomotives, steam machinery, machine tools, and all kinds of mechanical devices and military equipment. As a result, the RLM JSC was given a government order and a loan to build steam locomotives a few months before plant construction began (Voskresenskij, 1958, p. 7).

On July 31, 1895, an agreement was concluded between the RLM JSC and the Administration of State Railways for the annual production of 150 steam locomotives (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 25).

On August 6, 1895, the Board of the RLM JSC agreed to be joined in the construction of the plant by French society, assuring a 10-percent profit on the entire revenue of the plant, but not less than 500,000 francs a year (Voskresenskij, 1958, p. 8). The Board of the RLM JSC approved the technical service of the plant presented by the Bouet Plant Company. The Bouet Plant Company undertook the following obligations:

“During the twelve years since the establishment of the RLM JSC... render its cooperation at no charge, so that the RLM JSC might benefit from its experience in building and have the assurance that:

- 1. the workshops to be built shall be arranged according to the technical excellence required by this kind of factory business;*
- 2. once established, these workshops shall be allowed to enjoy all the advances that have been made in terms of equipment”.*

Furthermore, once the machine tool workshops were launched, the Bouet Plant Society was required by contract to refuse to supply the Russian Empire with any machine tools that could compete with the Russian Company. In return, the RLM JSC refused to supply machine tools outside the Russian Empire without prior agreement with the Bouet Plant Company. Of the shares issued for the execution of the share capital of the RLM JSC, the Bouet Plant Company was bound to purchase three thousand shares from the RLM JSC at 125 rubles in gold each bearing a payment of 375,000 metallic rubles.

The stage of construction and technological equipment of the plant.

On July 20, 1895, the Board of the RLM JSC invited Pavel Rizzoni, a technical engineer, to the construction of the Kharkiv plant with a salary of 12,000 gold rubles a year, and entrusted him with the purchase of a land plot in Kharkiv for the construction

of a locomotive plant and assigned him to manage the construction activities (Voskresenskij, 1958, p. 7).

Following the purchase of the land plot to build the plant, on September 18, 1895, the Board of the RLM JSC issued the following power of attorney to Rizzoni (Voskresenskij, 1958, p. 8):

“The Board of the Russian Locomotive and Mechanical Joint Stock Company, entrusting Pavel Pavlovich Rizzoni, a technical engineer, to manage the construction of the Company's locomotive and mechanical plant in Kharkiv, authorizes him to communicate and negotiate with governmental and public institutions and private individuals on all matters relating to the above construction; to conclude agreements and contracts on the construction of the plant; to procure materials necessary for the work; to make orders to contractors and suppliers; to make cash payments for the work performed; to hire employees for the plant and the technical office; to approve drawings and methods of technical constructions; to file motions in the Company's affairs at all judicial and administrative institutions; to file claims and, upon submission, to defend them; to file all kinds of petitions, reviews, letters of appeal and complaints; to receive documents, writs of execution and money; to give power of attorney to other persons. Whatever Rizzoni, or persons authorized by him, do under this power of attorney, the Board accepts and shall neither quarrel nor interfere with”.

The director of the Kharkiv Locomotive Plant, Pavel Rizzoni visited the machine building factories of Usines Bouhey and The Société Alsacienne de Constructions Mécaniques in France in 1895 prior to launching the Kharkov plant (Kulikov, 2015).

In October 1895, the Board of the RLM JSC invited A. I. von Goghen, an academician, to join its staff and entrusted him with drafting estimates and construction projects for all the factory buildings, as well as supervising their construction (Voskresenskij, 1958, p. 8).

In late October – early November 1895, the following construction operations began on the plant's main facilities: production buildings and workshops (steam locomotive assembly, foundry, modeling, copper foundry, forge, and boiler shop); power plant; main office; pass office; plant director's house with all services; a house for 24 apartments for families of craftsmen, heads of departments and workshops; two and three-story houses for guest engineers, technicians, and senior office employees; a 100-bed house for single workers. Over 1,700 employees were employed in construction (Voskresenskij, 1958, p. 11).

Construction of the main facilities of the expected plant was deployed on the eastern outskirts of Kharkiv (Balashovka area), on the vacant land between the freight station commissioned in 1895 by South-Eastern (Kharkiv-Balashivsky) Railway and Cyril and Methodius cemetery (today, Park of Machine Builders). The new plant was built specifically for the production of steam locomotives for the Russian state railroads.

The construction of the plant facilities was initiated by laying the foundation of the iron foundry with an area of 2,320 m², with a total length of 70 meters, and a total

width of two 33-meter spans (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 26).

On November 10, 1895, a general meeting of the RLM JSC shareholders was arranged. The following positions were approved during this meeting: plant management formed by the director, assistant director, chief accountant, and director's secretary; plant administration formed by the plant manager, assistant manager, head of the pass office, and the plant's office. The Board of the RLM JSC decided to complete the steam locomotive and machine-building departments of the plant by 1896, and by 1897, to postpone the construction and equip only that part of the plant buildings, which would not significantly affect the fulfillment of orders for steam locomotives already received by the government. The Board ordered 89 complex machines for equipping the plant for the amount of 420,635 gold rubles from the Bouet Company in Paris and approved a cost estimate for the construction of the plant. Out of the total sum of 4,603,370 rubles, 1,316,000 rubles were allocated for constructing the buildings of the steam locomotive department, and 1,839,195 rubles for equipping it with machinery and machine tools (Voskresenskij, 1958, p. 11).

In November 1895, long before the plant was supposed to be commissioned, the issue of housing for workers became urgent. The director suggested a plan to build a workers' camp for the Board of the RLM JSC. He asked to allocate 450,000 rubles for this purpose. However, the Board deemed such costs unaffordable and burdensome and having therefore rejected Rizzoni's proposal, only financed the construction of barracks and houses, which would have been profitable to operate. The decision of the Board stipulated the following (Voskresenskij, 1958, p. 12): *“The barracks shall be built by the household method, in the least expensive way possible, to house as many of the workers as may be required”*. The director adopted this decision without any objection and undertook the construction of the barracks. Somewhat later, the director of the plant initiated a plan to build special commercial houses that would be both self-refunding due to high rents and profit-making. These houses were intended mainly for highly paid employees and the “working aristocracy”. The Board adopted the plan and the estimate. However, since prices for plant apartments for workers were 1.5 times higher than average city prices, hundreds of working families, unable to pay the high rent, sheltered in cramped and uncomfortable barracks, while apartments in the new buildings remained unoccupied.

On July 30, 1896, the Board of the RLM JSC passed a proposal by the director of the Rizzoni plant to manufacture 120 steam locomotives annually, starting from 1898 (Voskresenskij, 1958, p. 12).

Early in August 1896, the main production facilities of the plant were completed. It was the main office of the plant, as well as steam locomotive assembly, forge, and iron foundry were built and partially put into operation.

The first iron castings were produced by the iron foundry less than a year after construction began, and its output was used for shop equipment with machine tool

stands, roof trusses, and rafters (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 27).

In September 1897, the following workshops were completed: machine-building, copper foundry, modeling, boiler shop, and paint shop (Voskresenskij, 1958, p. 134).

In October 1897, members of the RLM JSC Board from St. Petersburg came to the construction site of the plant. It was attended by A. I. Muranyi and A. I. Grube who inspected the construction and concluded that the main shops and departments of the plant could be commissioned.

In November 1897, the RLM JSC meeting formally decided to start up the plant. The decision stated (Voskresenskij, 1958, p. 13):

“Whereas the constructions and equipment at the Kharkiv Locomotive Plant, designed under an agreement with the Administration of the State Railroads of July 31, 1895, for the annual production of 150 steam locomotives and the estimates, approved by a general meeting of shareholders on November 11, 1895, are now completed, the construction and equipment of the Kharkiv Locomotive Plant... shall be deemed to be completed by November 1, 1897”.

Thus, November 1, 1897, was officially marked by the completion of the stage of construction and technological equipment of the KhLP.

The stage of development and establishment of the plant (1897–1914).

In 1896–1897, steam locomotive building and machine-building departments (divisions) were formed at the plant, including model, tool, and material warehouses; model, tool, iron foundry, copper foundry, forge, machine-building, steam locomotive assembly, and boiler workshops (shops). Since 1902, KhLP started producing steam boilers not only for its production (steam locomotive boilers) but also for the outside (boilers of different types and purposes) (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

Moreover, the boiler department was established as part of the machine-building department. In 1903, such workshops as copper and ammunition were put into operation. In 1906, following the reconstruction of the plant, repair, and construction shops were put into operation. In 1909, by the decision of the board of the RLM JSC, the loans were allocated for the reconstruction of the plant aimed at producing internal combustion engines (gas and oil), agricultural machines, and high-power steam locomotives. In this regard, Ya. P. Korobko (1907–1917), the director of the KhLP, submitted a plan for the reconstruction of the plant, suggesting an implementation period of 6–8 years and a cost of up to 2 million rubles (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 35).

During 1911–1912, such departments as heat engines and agricultural machinery were formed at the plant, and accordingly, the “heat” (for the production of internal combustion engines) and “agricultural tools” shops were commissioned; the iron foundry and forge shop were upgraded; installation of a powerful press to produce crankshafts for steam and internal combustion engines was begun and the copper

foundry was expanded (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 28).

In 1914, the steel foundry was completed, and the agricultural tool shop was converted into a wagon shop. In 1916, the steel foundry and bolting shop were commissioned (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 26).

For the first six years after the startup, the plant had a guaranteed state order for steam locomotives and was developing as a specialized steam locomotive plant, launching its “minor” metallurgical production. The first O^D class steam locomotive (O^A in Russian) was produced on December 5, 1897 (Gutnyk, Tverytnykova, Radohuz, Krylenko, & Tkachenko, 2021).. However, in 1897, KhLP ended up reliant on outside iron and steel factories, which led to an increase in turnover, stocks of raw materials, and supplies in warehouses (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 27).

In 1899, the plant hit the normal production cycle with a gross output volume of 5,546,000 rubles. In 1902, owing to a considerable increase in steam locomotive production, the gross output amounted to 6,940,000 rubles. Since 1903, up to the outbreak of the First World War, the annual gross output of the plant stabilized, not exceeding 6,000,000 rubles (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 35).

In 1903, the plant got its first orders from the Navy Department, which initiated the process of mastering the production of different types of machinery apart from steam locomotives. In particular, by order of the Navy Department, the plant manufactured such large-size machine tools as armored shaping, radial drill, lathe, chiseling, as well as a hydraulic press, and cranes. (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

Since 1904, KhLP mastered the production of certain types of engineering equipment, such as overhead cranes, presses, pumps, and drilling machines. According to the documents of the Navy Department, for the first time, the plant was officially named Kharkiv Locomotive and Mechanical Plant (Tsvetkov, 1990, p. 96).

During the Russo-Japanese War of 1904–1905, KhLP fulfilled an order from the Navy Department for 100,000 shrapnel shells (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

In July 1906, KhLP joined the “Steam Locomotive Union” which included Kolomna Locomotive Plant, Putilov Plant, Bryansk Machine-Building Plant, Sormovo Plant, and Luhansk Plant. This union assisted in getting additional orders for steam locomotives and provided conditions for the development of new steam locomotives based on cooperation and competitive process. In 1909, the KhLP started producing agricultural tools and machinery, such as plows, harrows, haymakers, and threshing machines. These products have repeatedly been awarded imperial diplomas at all-Russian exhibitions, and in 1911–1913, these products have received 38 medals (9 of them gold): 12 (3 of them gold) for the plows; 7 (1 of them gold) for harrows; 9 (2 of them gold) for seeders; 8 (2 of them gold) for reapers; 2 (1 of them gold) for horse

threshers. By 1912, the refitting of some workshops for the production of internal combustion engines (ICE) was completed and a new “heat” workshop was established. Production of ICE, as compared to the steam locomotive and boiler construction, required a higher level of production technology (in terms of accuracy class, quality and strength of materials used, technical level of personnel training and their qualifications), as well as production equipment given the lack of experience in ICE production and operation at the plant (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 32).

In 1914, the plant commissioned its first in-house iron and steelmaking production. Internal “backyard furnaces” fully met the needs of production in castings and forgings, as well as external orders. Such production arrangement ensured a reasonable combination of related machinery branches. Apart from steam locomotives, the range of mastered engineering products during the first 15 years after commissioning included boilers, pumps, compressors, internal combustion engines, machine tools, agricultural machinery, and tools (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, pp. 12–13).

Down to 1917, the KhLP, fulfilling state orders, developed independently within the RLM JSC system in terms of securing additional orders and was able to manage its profits alone. In particular, the KhLP accepted orders for spare parts and all kinds of repairs for every steam locomotive type (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 29).

Before the revolution, the KhLP offered the highest wages compared to all the enterprises in Kharkiv. However, during the First World War (1914–1917), the plant was forced to switch completely to the execution of state military orders (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 14).

The Kharkiv Locomotive Plant in 1916 – one of the argest plants in the region – was very complex, with departments, subdepartments and a hierarchy of professional managers (Kulikov, 2015). Each unit within the plant had its own administrative office, some of them were even housed separately from the main buildings of the plant. Theoretically each could operate as an independent business enterprise. Considering the structure of the Kharkiv Locomotive Plant and some other major companies we can say that by the beginning of World War I there existed modern enterprises in South Russia, which were characterized by a standard functional division of production: research and development, production, marketing, finance and accounting. The joint-stock form of entrepreneurial activity arrived to Russia as an already fully formed institution after several centuries of development by European lawyers and merchants. The adoption of this type of business organization by itself can be considered as a transfer of Western innovation.

A brief analysis of the designs of locomotives produced by the Kharkiv Locomotive Plant from 1897 to 1914.

***O* class steam locomotives.**

O class (main; “ОСНОВНОЙ” in Russian) was the first steam locomotive that became the basic one in the locomotive fleet of Russian railroads (Rakov, 1995). Between 1890 and 1915, twelve steam locomotive plants of the Russian Empire produced over 9 thousand locomotives of this series, which made the *O* class locomotive the most mass-produced of the pre-revolutionary locomotives. This locomotive was employed on all state and most private railroads of the Russian Empire, as well as on all railroads of the Soviet Union. The best known (and mass) varieties are the O^V (O^B in Russian) and O^D (O^A in Russian), nicknamed “ovechka” and “joika”, respectively.

The Kharkiv-Mykolaiv railroad was one of the first to receive new *O* class steam locomotives from the Kolomna Locomotive Plant. During the first year of their operation (1895), it was found out that in comparison with steam locomotives of 0-4-0 *Ch* (*Ч* in Russian) class which had a simple machine and steam pressure in the boiler 2 kgf/cm² lower, the new locomotives were not cost-effective since coal overspending reached 9%, even though the weight of trains had not been changed. A similar problem with O^D class steam locomotives was experienced by other railroads as well. Therefore, in 1896, at the XVII Consultative Congress of Traction Engineers, the Ministry of Railways raised the issue of constructive shortcomings of these steam locomotives for discussion (Rakov, 1995). As a result, it was resolved to make 99 changes in the steam locomotive design, of which the increase of wheel diameter from 1,150 to 1,200 mm and the increase of steam pressure in the boiler from 11 to 11.5 kgf/cm² (the latter was required to maintain traction force) were particularly worth mentioning. Production of new drawings was entrusted to Kolomna Locomotive Plant.

O. I. Hleb-Koshansky, director of Kolomna Locomotive Plant, based on the point, made by A. P. Borodin about the necessity to make different cutoffs of low- and high-pressure cylinders for the compound machines, suggested setting a cutoff of 0.5 of the large cylinders with a cutoff of 0.4 of the small cylinders (Westwood, 1982). This is how the “normal type steam locomotive of 1897” arose, which in 1912 was assigned with O^D class, meaning the “basic type” with Joy valve gear and increased wheel diameter (Rakov, 1995).

It is worth noting here how important for the development of railway machine-building were the Consultative Congresses of Traction Engineers. The first Congress, initiated by the famous scientist N. L. Shchukin, was held in Moscow in 1879. This and subsequent Congresses covered issues related to the choice of technical policy in the construction and operation of steam locomotives, the focus of scientific developments, as well as identified ways to modernize the rolling stock. Further Consultative Congresses were held alternately in different cities of the Russian Empire. Due to the positive impact of these Congresses on the development of the industry, their experience was adopted by other railway services (track and traffic). Similar scientific and technical forums became practiced internationally as well.

Besides the Kolomna Locomotive Plant, all enterprises of the Russian Empire that had the opportunity to build steam locomotives began producing “normal type steam

locomotive of 1897”. Thus, the “normal type steam locomotive of 1897” originated the stream locomotive construction at the Kharkiv, Sormovo, and Luhansk Plant. Steam locomotives of this type were produced from 1897 to 1903 and were widely used at the state and many private railroads of the Russian Empire.

***O^D* class steam locomotives.**

From 1897 to 1903, the Kharkiv Locomotive Plant produced 733 *O^D* class steam locomotives (Figure 1).. These were four-axle locomotives of the so-called basic type (hence the letter “*O*” by the Russian word “основной”) with a steam engine capacity (depending on the modification) of 550-720 hp (Kharuk, 2019, pp. 8–9) and a Joy valve gear. Their axle formula was defined as 0-4-0, where the middle digit indicates the number of leading axles (with large-diameter wheels; the more powerful the locomotive, the more leading axles it has). The first digit indicates the number of guide axles (in front of the leading axles; their purpose is to reduce the probability of the locomotive derailing when passing curves), and the third digit indicates the supporting axles (located behind the leading axles and designed to reduce the loads on them).



Figure 1. Blessing the first “normal type” *O* class steam locomotive at the Kharkiv Locomotive Plant (Malyshev Plant, n. d.).

***O^V* and *O^K* class steam locomotives**

In 1901, the XXIII Consultative Congress of Traction Engineers addressed the operation of the “normal type steam locomotive of 1897” (*O^D*) once again, resulting in several recommendations for design changes. Among these changes the most serious were the following:

1. Using lever-spring valves instead of the safety valves of the English engineer John Ramsbottom (1814-1897);

2. Adopting four-axle tenders along with three-axle tenders;
3. Installing the Walschaerts valve gear instead of the Joy valve gear.

The modernization, carried out according to the suggestions of the XXIII Consultative Congress, resulted in a steam locomotive that was designated the “1901 normal type”. Like the “1897 normal type” steam locomotives, the new locomotives were manufactured by Russian plants in rather large quantities. Moreover, these steam locomotives were produced both with the original Walschaerts valve gear and a modified one by the Kolomna Locomotive Plant. Over the course of production, the design of steam locomotives underwent some changes, and steam pressure in the boiler was raised to 12 kgf/cm². Steam locomotives with the modified design were named “1904 normal type”. In 1912, steam locomotives with the original Walschaerts valve gear were designated as an O^V class (by the Russian phrase “основной Вальсхарта” meaning the Walschaerts main type), and steam locomotives with a modified valve gear were designated as an O^K class (by the Russian phrase “основной коломенский” meaning the Kolomna main type).

From 1901 to 1905, the Kharkiv Locomotive Plant produced 271 “1901 normal type” steam locomotives and 269 “1904 normal type” steam locomotives.

Following 1907, when the steam locomotive plants began mass production of the more powerful and high-speed steam locomotive of the “Shch” “1905 normal type” class, production of O^V steam locomotives dropped sharply. From 1908 to 1915, the Kharkiv Locomotive Plant produced only 130 steam locomotives of this class.

***Shch* (Ш in Russian) class steam locomotives.**

From 1906 to 1916, the Kharkiv Locomotive Plant was manufacturing *Shch* class steam locomotives (Figure 2).

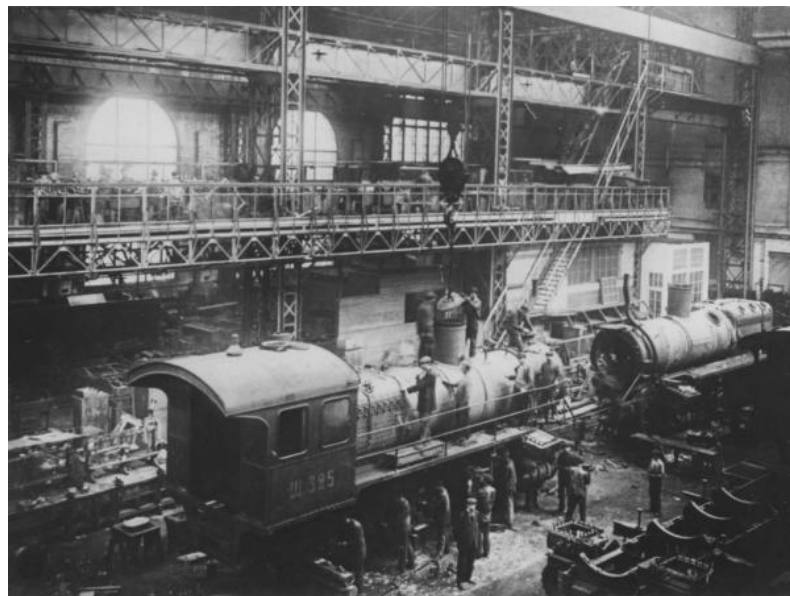


Figure 2. Construction of the *Shch* class freight locomotive designed by Kharkiv Locomotive Plant, in the 1900s. (Malyshev Plant, n. d.).

Due to the mass replacement of light and worn-out rails by heavier ones on state-owned railways and the need to discharge a significant number of 0-3-0 steam locomotives built in the 1850s and 1860s, it was reasonable to introduce more powerful steam locomotives. Therefore, in 1905, Minister of Railways K. S. Nemeshaev instructed Professor N. L. Shchukin to prepare a design of a new type of freight locomotive for state-owned railways (Strelko & Pylypchuk, 2021b). At this time, steam locomotives of the 0-5-0 type were already operating on some railways in Europe, but Professor N. L. Shchukin decided to stick only with the 1-4-0 type (Figure 3), taking the *Shch* class steam locomotive of the Chinese-Eastern and Vladikavkaz Railways as the basis for the project. To gain experience of operating these locomotives on state-owned railways, 10 *Shch* class locomotives of the were sent to Ekaterininsk Railways, and one to the South – Western Railways. However, this was done with a delay.

After the work of various commissions, the technical bureau of the Kharkov Steam Locomotive Plant under the guidance of engineer O. S. Rayevsky in 1906 designed a freight steam locomotive with a two-cylinder machine compound type 1-4-0 (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022). In the technical documentation, the new locomotive was known as the “Chinese-Eastern Railway modified type 1-4-0” or “normal type 1905” (Figure 4). In the same 1906 Kharkiv plant built the first steam locomotive of the “normal type of 1905”, which received the designation Yuh3501 and was sent to the Ekaterinisk Railway. In 1912, such locomotives were designated as the *Shch* class after the name of Professor N. L. Shchukin.



Figure 3. *Shch* class freight locomotive designed by Kharkiv Locomotive Plant (today, the Malyshev Factory). In total, about 2000 Sch class locomotives were manufactured by different plants in the 1900s – 1920s (Malyshev Plant, n. d.).

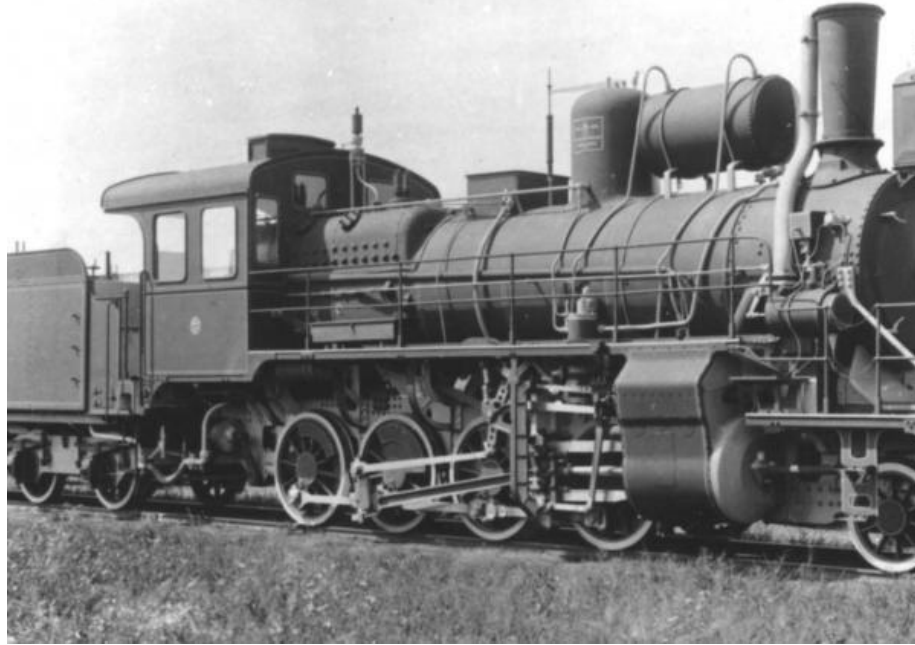


Figure 4. The freight locomotive, designed by the Kharkiv Locomotive Plant (today, the Malyshev Plant) was originally called “East China Railway Type”, by the name of the first railway customer. In 1912, locomotives of this type received the designation *Shch* class (Malyshev Plant, n. d.).

The results of the locomotive building at the Kharkiv Locomotive Plant in the late XIX – early XX century.

Since the commissioning of the Kharkiv Locomotive Plant, up to the outbreak of the First World War, steam locomotive construction was the main type of production activity of the enterprise.

A specific percentage of steam locomotive construction by year (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 28): 1897–1902 – 100%; 1902–1903 – 91.6%; 1903–1904 – 92.2%; 1905–1906 – 95.2%; 1907–1908 – 93.2%; 1908–1909 – 92.2%; 1909–1910 – 91.1%; 1911–1912 – 67.7%; 1913–1914 – 79.0%; 1914–1915 – 80.0 %; 1915–1916 – 80.0%.

By late 1903, the KhLP had built 1000 steam locomotives; from 1897 to 1912 – 1846 steam locomotives (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 30). By 1915, the KhLP accounted for over 20% of all steam locomotive production in Russia (Zaborsky, 2001).

Discussion.

The current situation in the railway sector of Ukraine is largely similar to the one that took place in Ukraine before the revolution of 1917. It implies not only high rates of construction but also the widespread use of private investment, as well as a unity of interests of the state and individual enterprises. Therefore, a retrospective analysis of the formation and development of the railway industry in Ukraine, the establishment

of financial management, and control of this industry are now gaining both scientific and important practical importance. Historical experience proves that it is the clear organization of state management of the railway industry that can ensure its stable and dynamic development, as well as the alignment of national and private interests in the economic sphere (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022; Kulikov, 2015; Medvedeva, Kucher, Lipsa, & Hełdak, 2021; Shtepenko & Vergeles, 1997; Yeremenko, & Kroytor, 2020). In this regard, the authors believe that it proved to be extremely important to turn to the history of the development of railway transport in the Russian Empire in general, and the beginning of the production of the first steam locomotives in Ukraine at the Kharkiv Locomotive Plant, in particular.

Many researchers admit that the Russian Empire in the early XX century was a leader in the theoretical development of new types of traction and their practical application in transport; internal combustion engines; power supply systems (Gutnyk, Tverytnykova, Radohuz, Krylenko, & Tkachenko, 2021); the development of devices for rolling stock (Sorochynska, 2015a); and the development of track facilities (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022). The need for new railways and the lack of funds for their construction were compensated by improving the management structure (Kulikov, 2015).

The economic growth rate of the Russian Empire in the late XIX – early XX centuries was quite high, but the country still lagged far behind the industrialized West. There was an obvious need for transition to a qualitatively different level of development, related to the use of advanced experience in the evolution of science and technology. Engineers of different steam locomotive designs became the creators of the theories of motion, construction, and applied mechanics, as well as the pioneers in the use of new materials in the manufacture of steam locomotives. It can be said that their efforts resulted in the creation of the national school of locomotive engineers, one of the best at that time. Among their leading representatives were the locomotive engineers of the Kharkiv Locomotive Plant.

Conclusions.

This article discusses the conditions and prerequisites for choosing the location of the plant; considers the stage of the establishment (foundation) of the plant; examines the stage of plant construction and equipping it with technological facilities in detail; analyzes the development and establishment of the plant between 1897 and 1914. A brief analysis of locomotive designs produced by the Kharkiv Locomotive Plant from 1897 to 1914 has been made. The article shows the significance of Consultative Congresses of Traction Engineers for the development of railway machinery both at Kharkiv Locomotive Plant and for the entire railway industry.

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Conflicts of interest.

The authors declare no conflict of interest.

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Передумови створення, подальшого розвитку та становлення Харківського паровозобудівного заводу

Анотація. Кінець 19 століття – період підйому промисловості в Російській імперії, що характеризується переміщенням центру промислового розвитку з Уралу на південь країни, у зв'язку з початком розробки багатих вугільно-рудних родовищ на території України, що супроводжується інтенсивним будівництвом залізниць у центральній та південній частині Російської імперії. Це стимулювало розвиток машинобудівних галузей, в умовах протекціоністської економічної політики уряду Російської імперії по відношенню до російських підприємств, з метою убезпечення їх від впливу зарубіжних конкурентів. На початку 1870-х Харків починає швидко розвиватись як великий промисловий центр півдня Російської імперії. Залізниця створила умови для доставки найпередовішого обладнання та технологій, чим не

преминули скористатися представники іноземних компаній. У 1890-ті роки значний розвиток набуло транспортного машинобудування. Починаючи з 1891 року було порушено монополію на паровозобудування у Російській імперії, яке було зосереджено у 1880-х роках одному лише Коломенському заводу. У 1890-х роках паровозобудування розгортається на восьми найбільших машинобудівних підприємствах Російської імперії. Метою статті є ґрунтовний аналіз передумов створення, подальшого розвитку та становлення Харківського паровозобудівного заводу. Запропоновано періодизацію різних етапів історії Харківського паровозобудівного заводу. У статті проаналізовано умови та передумови вибору місця будівництва заводу; розглянуто етап заснування (підстави) заводу; детально розглянуто етап будівництва заводу та оснащення його технологічним обладнанням; проаналізовано етап розвитку та становлення заводу в період 1897–1914 років. Виконано короткий аналіз конструкцій локомотивів, які виготовляв Харківський паровозобудівний завод з 1897 по 1914 роки. У статті показано наскільки важливе значення для розвитку залізничного машинобудування, як на Харківському паровозобудівному заводі, так і для всієї залізничної галузі загалом, мали дорадчі з'їзди інженерів служби тяги.

Ключові слова: паровоз; історія паровозобудування; Харків; паровози “нормального типу”; паровози класу “О”; паровози класу “Щ”

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Russian aviation industry and First World War challenges

***Abstract.** The purpose of this study is to highlight the peculiarities of the development of the Russian aviation industry during the First World War. The focus is on analyzing production programs and matching their quantitative and qualitative parameters to war requirements. The main methods used in our work are problem-chronological, used to describe the state of the Russian aviation industry, and comparative, used to compare the level of development of the Russian aviation industry with other countries that participated in the First World War. General scientific methods have also found their application – primarily, analysis and synthesis. The*



research resulted in the following conclusions: First World War became a challenge for Russian industry that was in the developing stage, including aviation industry. Needs of the front demanded for increase in plane productions that was a complex task for Russia, taking into account its economic backwardness. Aviation industry, being represented by several big (in the scope of Russia) enterprises, demonstrated a dynamic of growth. For the war period the plane production capacity had increased only in 3 times while in Germany – in 10 times and in France and Great Britain the growth was much bigger. Leading enterprises of aviation industry, such as factory of Duks, Liebiédiev, Anatra, Shchetinin – mainly copied foreign samples (French, and sometimes German). Efforts to establish the production of original samples were a complete failure. The most known example is fighter “Illia Muromets” that was a leading one in 1914 but became old-fashioned till 1917. Aviation engine production was also narrow and was far beyond plane production. Enormous investments made in the development existed and building of new enterprises of planes and aviation engines production in 1916–1917 did not show any results, none of the enterprises started the production. We have analyzed some of these failures – building of Anatra factory in Simferopol and Matias factory in Berdiansk, and aero-motors factories Anatra in Simferopol and Deka in Aleksandrovsk. State police on controlling aviation industry based on providing subsidies and preferential loan, turned to be ineffective – it was vanished by basic purchasing prices that did not count on inflation. That is why Russian aviation industry appeared to be unable to face and respond to war challenges. Production plans of leading Russian aviation factories as well as qualitative and quantitative parameters of products have been analyzed in the article.

Keywords: *aviation industry; aviation plant; military aviation; military aircraft; Russian Empire; First World War*

Introduction.

War that commenced in August 1914 that was marked in the history as First World War became the first war of engines. The very modern inventions, among which were plane, were used during the war in great scale and scope. At the beginning very primitive planes, able to conduct recce flights, they became one of the main means of combat action conduct. Not only recce planes but also bombardment aircrafts and fighter planes became widespread. The field that was represented by almost small industrial enterprises prior to the war, turned into highly developed industry which utilize leading achievements in technology.

In 1914 France occupied the leading role in development of aviation material. Germany and Great Britain was just beyond France. The Russian Empire as Austro Hungary and Italy related to the “third class” of aviation countries. We did not take into account quantity of planes in military aviation (Russia was a leading country in the quantity of planes), but qualitative characteristics of aviation-industrial complex: its capabilities to produce modern planes of own projects and the quantity of planes` production should meet forces` needs.

The moment the Russian Empire entered the war led to the growth in production of armament and military materials and planes as well. One of the crucial factors that led to the growth in production was that delivery from abroad became difficult – Russian had to substitute foreign samples by own ones at least partially. Planes utilization in the field led to their accelerated run-out. The period of plane utilization to overhaul was two/three months and the overall lifecycle was not more than nine months. All these and combat losses demanded for increase in planes delivery.

Russian aviation enterprises received big contacts that exceeded the amount of orders that were prior to the war in almost 10 times. This pushed enterprises owners to develop the industrial base of existed factories and to establish new enterprises. Gradually a tendency appeared that marked the transition from licensed production of foreign samples to plane production based on own projects. We will do a comparative analysis of development strategies of main Russian enterprises of aviation production based on the published works and archive sources. We will answer some core questions: 1) To what extent Russian aviation industry was ready to the war? 2) Was it able to meet the needs of military aviation in its quantitative side? 3) Did the planes quality of Russian production meet the time requirements?

Research methods.

In the Soviet historiography, the development of the aviation industry during the First World War has been fragmented. In the general context of aviation development, P. Duz' considered this problem (Duz, 1989). In his fundamental research on the development of aircraft, V. Shavrov also briefly addressed the state of the aviation industry (Shavrov, 1978). In post-Soviet Russian historiography, there are two groups of research relevant to our work. The first of these are publications on the general development of the Russian aviation and aviation industry (Soboliev, 2011; Kulikov, 2014). The second group consists of works on the specific types and classes of aircraft that were manufactured in the Russian Empire during the First World War (Khairulin, 2010; Maslov, 2021; Aleksandrov, 1998; Petrov, 2000). Ukrainian historiography is rather modest work on the subject of our research – the works of V. Savin and A. Kharuk, which discusses the development of the aviation industry in Ukraine (Savin, 1995; Kharuk, 2010; Kharuk, 2020). The source of our work was the materials of the F.s of the Russian State Military History Archive.

The achievement of the set goal was facilitated by the use of problem-chronological and comparative methods. Their combination made it possible not only to reveal the state of the aviation industry of the Russian Empire during the First World War, to show the problems of its development, but also to compare it with the state of the aviation industry of other leading countries.

Industrial Giants – Duks and RBCF (Russian Baltics Carriage Factory).

Analyzing the process of Russian aviation industry formation, we can identify two options: development of planes production on existed machinery-building enterprises

and establishment of new specialized enterprises. The most typical example of the first option is Duks factory in Moscow which was previously responsible for bicycles and motorbikes production. Mr. Yulii Meller, Baltis German, was the owner who changed his last name into a Slavic Briezhniev after the beginning of the war.

In autumn 1910 Duks factory produced airship “Yastreb” but there was no further development of this airships production. Instead the owner began more forward-looking production – plane production. Particularly most Russian researchers did not pay much attention to this factory. Meanwhile during the First World War Duks occupied the first position in Russian based on the amount of production. From July 1914 till January 1917 this factory produced 1569 planes that made almost 1/3 of general Russian products (Kulikov, 2014. p. 266). What is the reason of such concealment? In our perspective the thing is that Meller-Briezhniev only duplicated French models not even trying to pursue own projects. Soviet historiography and most of modern Russian historians proved that such a position of the businessman showed a lack of trust to domestic designers and that is why deserves only a negative grade. But from business perspective this strategy is transparent. It is possible to duplicate ready-made samples without involvement of highly paid specialists. There were only 6–7 engineers in the technical branch of Duks factory (2300 personnel worked in the factory in 1917) (Kulikov, 2014. p. 267). More over duplication was often made with the license being purchased – but through reverse engineering. Putting aside law aspects it should be said that it allowed to substantially reduce base cost of products. From consumers` point of view – Military Ministry – an approach the Duks factory stuck to, had some advantages. Duplication of tested models allowed to avoid the testing period of own product which sometimes could last very long. This accelerated the process of providing aviation units with materials (vehicles) that were of great importance in war condition.

What planes did Duks factory produce? Till mid 1916 a two-seat scout airplanes Morane L were its main products (known also as Morane Parasol; approximately 400 samples were produced), Morane G (75 samples) and Nieuport IV (more than 140). Simultaneously in August 1915 airplanes Voisin started to be produced. 150 samples of such an airplane were produced by a factory in Moscow. Starting from summer 1916 recce airplane Farman XXVII (50 samples) and Farman XXX (250) had been introduced. Production of the latest ones stopped only in January 1918. In the end, in spring of 1916, fighter aircrafts Nieuport appeared in production. Till December 1917 Duks had produced more than 460 of such fighter aircrafts of models X, XI, XVII and XXI. In such a way this factory became one of the biggest producer of fighter aircrafts in Russian. At the end of 1917 a production of modern planes of such class started to be produced, namely SPAD VII. They managed to produce only 17 such fighters till January 1918.

Duks factory was able to start large scale plane production (based on Russian parameters) due to putting efforts in duplication of French models. In comparison the other machinery building factory failed to do it, namely RBCF (Russian Baltics

Carriage Factory). This association, tighter with passenger, cargo and tram carriages, produced also farming vehicles, cars and other products. In spring of 1910 two engineers were sent to France to get acquainted with aviation achievement due to the initiative Head of Supervisory Board Mykhail Shydlovsky. After their coming back a RBCF aviation department was established in Ryga. Till autumn 1912 10 planes had been produced here, two out of them were experimental of Yakov Hakkel, one of Aleksandr Kudashev and seven – based on French sample Sommer (Shavrov, 1978, p. 140).

In 1912 Aviation department of RBCF was moved to St. Petersburg and Mr. Ihor Sikorsky, being invited from Kyiv, occupied the position of chief designer. This young engineer of 23 years was credible in aviation communities. In St. Petersburg he constructed experimental planes № 6B, № 7, № 8 (Mikheev & Katyshev, 2003, pp. 95–96). But there were no orders for such planes. Instead RBCF produced planes Bleriot, Nieuport and Farman on order from Military Ministry (in total more than 100 samples) (Mikheev & Katyshev, 2003, p. 147). Being forward-looking the Aviation Department focused on production of heavy four-engine plane “Illia Muromets”. The prototype of this plane began testing in December 1913. On May, 12 1914 Military Ministry signed an agreement on supplying 10 such planes. The first serial sample was produced in August 1914 (Khairulin, 2010, p. 30). Based on different sources, from 79 to 83 samples of planes “Illia Muromets” were produced, the latest of which were produced after Bolsheviky revolution.

RBCF produced several variants of “Illia Muromets” which differed in glider construction details, types of engines and armament. First serial variant, known as type B, was produced in 5 samples. One of them got engine Argus, others – Salmson. The crew consisted of 5 people but weight of bombs load reached 240 kg. First sample of type B was produced in December 1914. This variant was different in reduced length of fuselage and smaller wingspan. Armament comprised to machine guns Maxim or Madsen that were on the platform in the middle of upper wing. Bomb load reached 400 kilograms. 18 planes of type B were produced to 1916, nine out of them got Sanbeam engines, and others – other types of engines. The most numerable was type “G” (40 samples) which was different in increased upper wing chord. Those planes got different types of engines – Sanbeam, Argus, Renault, RBCF.6 and others. Some of them could change several types of engines during exploitation. Fighter aircrafts of type “G” were equipped with machine guns Maxim, Madsen and Lewis (from three to five). Bomb load was 400 kilograms. Production of type “G” started in March 1916. Bomber aircrafts of type “D” and “E” were also produced but in smaller set (Kharuk, 2014, pp. 162–163).

“Illia Muromets” was the first four-engine bomber in the world. The moment it appeared it was, without exaggerating, a unique aircraft. But “Illia Muromets” has serious defects in construction, mainly in aerodynamics. Moreover, it had problems with engines. All changes done during First World War were very shallow and did not lead to radical improvement in fighter aircraft parameters. In 1917 “Illia Muromets”

became completely old-fashioned. The intensity of these planes' exploitations is hard to name as a high: in total, one fighter which took part in combat actions, done only 7.5 combat flights. Besides, this quantity varied in broad bounds: if "successful" samples could have dozens of combat flights, others – only one-two flights (Kharuk, 2014, p. 166).

During First World War the Aviation Department of RBCF was booked with production and maintenance of bombers "Illia Mutomets". The thing is that the Squadron of Aircrafts – units where these planes were on service – was under command of M. Shydlovsky. It is transparent that under such circumstances Aviation department of RBCF had to respond to the needs of aircrafts squadron. Production of other samples of planes almost stopped though I. Sikorsky continued to construct new experimental samples. Prior to the war, RBCF produced a small set (13 samples) of one-engine aircraft Sikorsky № 13. In October 1914 Sikorsky produced a model №16. In this case a role model for him was an English plane Sopwith Tabloid. Conceptually, model № 16 was cavalry plane – not big speed scout (Mikheev, 1994, p. 8). In such a role Sikorsky № 16 (known as S-16) was not in use. In 1915 18 samples of S-16 were produced, forwarded to aircraft squadron to be used in training purposes. Later some of them were equipped with machine guns and were used as improvised fighters (Stamper, 2000, pp. 77–78). The second set of S-16 (15 samples) remained unfinished up to the times of Bolshevik revolution.

In this case, production capacity of Aviation department of RBCF during the First World War was booked with production of prestigious but ineffective heavy bombers. Light planes were not produced though there was a need of them in the front. But according to M. O'Neil, production of "Illia Mutomets" and S-16 demonstrated that Russia not entirely dependent of foreigners for innovative aircraft design and production (O'Neil, 2002, p. 154).

Factories of Shchetinin and Lebediev.

A range of aviation enterprises in Russia were established by aviation enthusiastic people. Not all of them achieved success: some of them went bankrupt having produced one or several experimental planes, another functioned as workshops being able to produce dozens of planes, and only some of them became real factories. Among them there are factories of Shchetinina and Lebedieva in St. Petersburg.

In 1909 Sergey Shchetinin, a lawyer and a businessman, established "First Russian Aeronautics Association" (FRAA) – first commercial enterprise in Russia which primary task was production of planes. In July, 11 1910 FRAA got an official permission from Ministry of Trade and Industry in Russia to open aviation factory (Soboliev, 2011, p. 18). Its first products were aircrafts Rossia A and monoplanes Rossia B (duplicate consequently Farman III та Bleriot XI). The factory produced 5 samples of each type. In 1912–1914 FRAA produced 57 planes Nieuport and 36 Farman of different types for Army Aviation (Aleksandrov, 1998a, p. 7). But the main factory production was seaplanes which were provided to Russian Naval Aviation.

From the period of creation up to 1917 the factory FRAA produced 1360 planes counting 1030 seaplanes (Kulikov, 2014, p. 231).

The key role in creation seaplanes in the factory FRAA played Dmitry Gryhorovych. This engineer, like Sikorsky, belonged to Kyiv Aircraft Construction School and later moved to St. Petersburg. He gained his first experience in naval aviation in summer 1913 when factory of Shchetinin received an order to repair a damaged aircraft Donnet-Leveque (of French production). Based on the received information an aircraft M-1 was produced, testing of which began in June 1914 (Petrov, 2000, p. 18). This model, in its turn, became basic for other more improved aircrafts which duplicates a scheme of one-engine two-seats flying boat with engine place between upper and lower wings. First Gryhorovych's seaplane which being produced in great quantity was M-5 with engine Gnome Monosupape with capacity 100 hp. From June 1915 183 aircrafts of such type were produced, the latest of which were produced in 1923 (Aleksandrov, 1998b, p. 7). M-5 stopped to meet time requirement as a combat plane because of low flight data (max speed did not exceed 105 km/h). But it continued to be widely used in Naval Aviation Schools to train pilots.

From April 1916 a company FRAA produced aircrafts M-9. From the second half of 1916 this type became the main one in Russian Naval Aviation and remained so until Russia withdrew from First World War. In comparison to M-5 this aircraft was different in having bigger size and more powerful engine Salmson (150 hp). M-9 was equipped with one machine gun and was able to carry up to 100 kg of bombs. Factory of Shchetinin produced approximately 240 samples of M-9. Development of this model led to appearance of aircraft M-15 which had smaller size and engine Hispano-Suiza (140–150 hp). M-9 was able to speed up to 110 km/h but M-15 with the same armament was able to speed up to 125-130 km/h. In November 1916 Fleet ordered 80 seaplanes M-15 and then decreased this number to 60. In 1917 there was an opportunity to produce only 30 samples of seaplane M-15 (Aleksandrov, 1998a, pp. 66–67). The reason was lack of engines.

Activation of German aviation in the Baltics led to the necessity of creation specialized seaplane-fighter. In summer 1916 in the factory Shchetinin M-11 was created, an average one-seat aircraft with an engine Monosupape (100 hp) or Le Rhone (110 hp), equipped with machine gun Maxim or Vickers. Based on M-11 another type M-12 was created. Russian fleet got 61 seaplanes M-11 and M-12 till May 1917. Factory of Shchetinin got orders to deliver more fighters but from May 1917 fleet stopped to accept them because of low flight characteristics. In July 1917 there were approximately 100 samples of partially constructed seaplanes M-11 and M-12 but they had been never finished.

Specific conditions of the Baltic Sea, significant part of which was covered with ice each winter, led to the appearance of another construction of Gryhorovych – “Winter M-16”. In comparison with previous seaplanes, M-16 was not a flying boat but a float plane. A flat floats let the plane take off either from sea, ice or snowy surface. This aircraft resembled French plane Farmana XXX. Seaplane M-16 had engine

Salmson (150 hp). Russian fleet ordered 40 samples of M-16 but the contract was not entirely completed: from December 1916 to June 1917 fleet accepted approximately 25 seaplanes M-16 (Aleksandrov, 1998a, pp. 72–73).

FRAA factory during the First World War was the main supplier of planes for Russian fleet. Its production covered the needs of Naval Aviation in quantitative figures but not in qualitative. Flight characteristics of Gryhorovych seaplanes were worse than their German opponent had.

There was also another aviation factory in St. Petersburg of Vladimir Lebediev named “Joint Stock Aeronautics Association”. In 1914–1917 this factory produced approximately 800 planes. Its early products were monoplanes Nieuport IV, Deperdussin TT and biplanes Farman of several models. In 1914–1915 the factory produced approximately 140 plane. Till 1917 reconnaissance biplanes Voisin started to be produced (215 samples). As Fleet ordered in 1914–1916 34 samples of FBA flying boats were produced based on French license. Planes Morane L and Morane G were produced as well but not in great amount (Kulikov, 2014, p. 244).

V. Lebediev paid attention to the development of his own constructions. Leopold Shkulnik, an engineer who worked in Germany in the AGO company before the war, was a chief of his designing office. It should be said that designing activities were displayed by the owner of the factory in ingenious way: he sold duplicated non-licensed samples of foreign planes or just repaired planes marked with his label tags. For example, in December 1914 two planes Lebed VII which were duplicated of Sopwith Tabloid were constructed. Lebediev sold the plane Lebed X to the Army. It was a trophy biplane LVG B.II being brought to the factory to be fixed but it did not prevent Lebediev from getting money as for a new one. Later he managed to sell nine more trophy planes-scouts of different types marked with Lebed XI tag (Kulikov, 2014, p. 246–247).

Maintenance of trophy German planes gave an opportunity to familiarize their construction. Based on this experience a new plane Lebed XII was constructed. It was an adaptation of two-seat plane-scout Albatros with engine Salmson. Testing of the prototype began in 1915. Testing results were almost satisfying and in February 1916 the factory received an order for production 225 samples of Lebed XII from Military Ministry. First set was forwarded to the Army at the end of September. In accordance with the contract all planes had to be delivered till July 1917 but the factory could not stick to the defined requirements: till the end of 1917 only 202 planes Lebed XII were produced (Maslov & Kulikov, 1998, pp. 10–12).

Anatra Factory.

The third center of aviation industry in the Russian Empire (after St. Petersburg and Moscow) was Odesa. In March 1908 the second flying club in the Russian Empire was established here, which was run by Artur Anatra, a banker and a businessman who was of Italian origin. There was also an aviation school at the flying club and a workshop where samples of French plane were constructed only upon receiving private

orders. Till the end of 1912 18 planes were produced there (fourteen Farman, three Bleriot and one Nieuport).

Besides based on Vasilii Khioni project a two-seat monoplane with engine Gnome was constructed here. Plane Khioni № 1 participated in an annual competition of military aircrafts which was organized by Military Ministry, but was damaged and did not fully complete the competition programme.

Anatra understood clearly that civilian market of aviation materials in the Russian Empire is limited and the only way to develop the production is to receive orders from military organizations. In June 1913 he was able to get a contract for five planes Farman XVI and it was done in November that year (Russian State Military Historical Archive [RSMHA], F. 802, D. 4, C. 2337, S. 84).

In January 1914 Anatra got new order to produce 8 biplanes Farman XXIIbis which were delivered to Military Ministry in July-August 1914.

In July 1914, 95 people worked there. That time it was a workshop at Odesa Aviation School of Artur Anatra but in the second half of 1914 it became a joint stock corporation. To create a design office Anatra invited Elisée Alfred Descamps, a French engineer (In Russian he was named as Dekan). Project of plane P20 was a prerequisite for further work which Anatra bought before the outbreak of the war in a German company Aviatik (Aleksandov & Petrov, 1997, p. 31). It was not by chance that this project had been chosen – E. Dekan was working there from 1912 till 1913 (Hornat, 2005, pp. 32–33). But the implementation of this plane into production was going too slowly that is why the production of Anatra factory was focused on planes of French type. The businessman himself was satisfied with stable benefits so did not want to risk by implementing a completely new plane.

As many other Russian enterprises Anatra factory produced a variety of place based on French projects. Mainly 4 samples of biplanes Farman – IV, XVI, XX and XXII were produced there. The first was used in the training purposes, the other three were different in wing size and other small technical improvements, were used in front though were not as good as enemy planes.

From November 1914 till February 1917 Anatra, based on the archive sources, got an order to produce 278 Farman planes. Almost half of them – 138 samples – were the most primitive Farman IV (RSMHA, F. 802, D. 4, C. 2415, S. 2). Plane Farman XVI was produced in small quantity – 15 samples were ordered in November 1914 and delivered to the Army till March next year. Till February 1916 the factory also produced 30 Farman XXIIbis planes (RSMHA, F. 2008, D. 2, C. 428, S. 1–2). Finally in December 1916 and February 1917 Anatra got another order to produce 95 Farman XX planes (RSMHA, F. 493, D. 11, C. 305, S. 64). First planes of this type were ready only in July 1917. That time Farman XX could be used in training purposes only.

The second place in production biplanes of French design was Voisin. As Farman, Voisin was considered to be of a very archaic design. But in comparison with Farman, Voisin had more powerful engine Salmson (130-150 hp). Moreover, this type of engine

was the only one that was produced in the Russian Empire in a great amount. This made Voisin planes so popular in Russian Army Aviation (Kharuk, 2020, p. 85).

Anatra company got three order to produce 200 Voisin planes for the period March 1915-February 1916 (RSMHA, F. 493, D. 4, C. 9, S. 10). But its production was delayed because of some objective and subjective reasons. Till August 1916 the Army received only half of the ordered planes. The delay resulted in Voisin plane becoming old-fashioned. Aviators from combat units tried to improve Voisin flight characteristics. The most successful was Lieutenant Petr Ivanov. His plane named as Voisin Ivanova (VI) got new compact crew gondola. There were also some changes in the design of landing wheels and wings. Due to this the speed increased on 20 km/h though the engine remained the same (Shavrov, pp. 177–178). Having made the construction of the plane lighter he managed to improve flight characteristics but it decreased the toughness of the construction. But it was identified later during the service in the front. Meanwhile the plane Voisin Ivanova was successfully tested. In October 1916 a decision was made to exchange production of 100 of non-ready planes LAS for the same amount of VI with the deadline till the end of the year. But in reality this delivery prolonged up to July 1917 (Kharuk, 2020, p. 87). This contract can serve as an example for tracking peculiarities of finance calculations between the company and state. Military Ministry bought two-seats scout planes (without engine and armament) for the fixed price – 13500 rubles despite the type of the plane and the production factory. Anatra asked to increase the price for 1000 rubles for each plane because of the changes being made in the basic project. But Military Ministry insisted on preserving the initial price, though the Ministry admitted the factory's loss for 720 rubels on each modified plane (RSMHA, F. 493, D. 4, C. 119, S. 19–20).

Not only biplanes were produced in Odesa but also monoplane of French type – Nieuport IV and Moran G. These two-seat planes were equipped with engine with capacity of 70-80 hp. At the initial stage these planes were used in the front as scout planes or light fighters (in this purpose they were equipped with bomb holder of Shchetinina system). Later these planes were used in aviation schools. The amount of production was not big – based on the existed data Anatra factory produced approximately 100 planes Nieuport IV and Moran G (Kharuk, 2010, pp. 56–57).

In May 1916 Anatra factory started to produce Anade planes (Anatra D, or Anatra-Dekan) which was based on P20 project but with an engine Gnome Monosupap (100 hp) instead of German Oberursel. During 1916 Anatra got a huge order to produce this plane (from Russian perspective) – 5 contracts for 759 planes (Kharuk, 2010, p. 59). First this company did very fast job and forwarded to the Army 35 Anade planes in May-June 1916. But this rush caused in troubles concerning enduring appropriate quality of the product – part of the planes was returned to the factory to fix some defects. Than the tempo of production decreased. Till September 1917 148 Anade planes were produced and till the end of the year this amount reached 225 samples (Russian State Military Historical Archive. F. 493, D. 11, C. 305, S. 64a). In such case Anatra factory managed to produce less than 1/3 of ordered planes and was behind the

plan. It should be said that Anatra factory is the only guilty one. The main factor was “engine hunger” – permanent lack of aviation engines. Because of this 47 planes were accepted without testing – there were no engines. Other 24 planes out of 225 got powerful engines Clerget (110 or 130 hp). This sample was named Anakler (Maslov, 2021, pp. 22–23).

At the moment of accepting Anade plane in the Army it was old-fashioned, its speed was not enough and weight of bombs load did not exceed 30 kg. The modernization way was transparent – installation of more powerful engine. There were almost no choices as we mentioned before that the only engine available in Russia was Salmson (150 hp.). Anade variant adapted to this engine was named Anatra DS (Dekan-Salmson) or Anasal.

Installation of more powerful but heavier engine caused the need to make a lot of changes in the plane design. Its size became bigger, engine frame was reinforced, and fuselage was lined with flywood (tail part of Anade fuselage was lined with cloth). To preserve the right centering, the upper wing was moved forward (Maslov, 2021, pp. 25–27).

Anasal prototype began testing in July 1916 but fixing process of defects continued to December. Only at the end of 1916 the Army ordered 400 samples of such planes and in July 1917 300 samples more (RSMHA, F. 493, D. 11, C. 305, S. 880). All 700 planes were produced till the end of December 1917 but in reality only 46 samples were forwarded within the announced timeframe. It was too late for Anasal plane to take part in the IWW.

Capacity building of production base.

Increasing need in combat planes in the front units caused the necessity of urgent expansion of production base of aviation industry as import of aviation materials was complicated because of war and available Russian enterprises could not meet the needs. That is why in 1916 Russian government initiated the support programme of domestic private entrepreneurs who considered the aviation industry as a chance to get profound benefits. Several aviation factories the building of which had already started or was about to start went beyond 15. We will consider some the most typical examples which illustrate three approaches of establishment aviation materials production: expansion of existed companies, creation of state enterprises and production of aviation materials of those enterprises which were not parts of that field before.

Expansion of the Anatra company became a typical example of first approach implementation. In March 1916 the owner of this company signed an agreement with military Ministry and in accordance with which he was obliged to build a factory in Simferopol during the following six months with the production capacity 20 planes per month. With this aim Main Military-Technical Department gave Anatra a grant for 300 000 rubles and interest-free loan – 340 000 rubles. The building of factory ended till the end of September 1916 (RSMHA, F. 493, D. 4, C. 119, S. 280). In October 1916 the Executive Committee at Military Ministry decided to order 150 Anade planes in

Simferopol factory. But in several days the decision was changed and from that moment the production of Anade planes was moved to Odesa. The factory in Simferopol received an instruction to get ready to the production of fighter planes Nieuport. The company received an order for 100 Nieuport XVII planes which had to be forwarded to the Army in April-May 1917 (RSMHA, F. 493, D. 11, C. 200, S. 5). According to the contract, the price for planes was 11000 rubles (without engine and armament) and it was a regular cost for one-seat fighter planes despite the type of it. But at the moment of contract signing there were some doubts concerning the deadline of its implementation. The reason was a well-known “engine hunger”. It was sending in the contract that only one out of five planes could be tested but Military Ministry was not able to provide even such a minimum of engines. That is why on October, 6 1917 Military Mentor at the Simferopol factory wrote out a card concerning receiving 50 Nieuport plane even without having them tested in the air – only by their appearance (RSMHA, F. 493, D. 11, C. 200, S. 47). It meant that the plane was officially forwarded to the Army and the company received its money but in reality planes were in the factory and there were no benefits for the Army.

An examination of Anatra factory in Simferopol done by state Committee in August 1917 revealed a very bad condition of it. There were 370 workers who worked at the factory. The factory facilities were ready to be used but only 60% of necessary equipment was installed. There was lack even in had machinery. The Committee admitted a low technical level, absence of effective management and bad road conditions. It was also revealed that highly qualified employees of aviation industry were involved to the production of furniture (RSMHA, F. 493, D. 11, C. 200, S. 67–68). So it is transparent that the state invested money into the factory but the Army did not receive any of the planes.

Matias factory can be an example of newcomer in aviation industry (Joint Stock Association “Matias widow and sons”) in Berdiansk near the Sea of Azov. This company was established in 1884 and dealt with agricultural vehicles and tools. Business was going smooth; in 1913 Matias occupied the eighth place out of 334 enterprises of agricultural machinery engineering in the Russian Empire based on the capital amount. That time there were approximately 500 employees. But the outbreak of the First World War caused the fall in payment demand for Matias products. It made the Council of Director think about the change of company specialty. They accepted P. Stefankevych proposal who was an engineer to initiate planes production. At the beginning of 1917 they started to repair working facilities and bought a land in the suburbs to build new workshops and creation of factory airfield. On June, 1 1917 Matias got an order for 100 scout planes Farman XXX with the deadline July-September 1917 (RSMHA, F. 493, D. 4, C. 561, S. 60–61). After completing this the company had to start the production of scout planes SPAD XIV. But the company failed: till 10 Dec 1917 Matias received 3,5 million rubles from the state to arrange plane production (debt exceeded the total cost of the factory), but did not produce any of the planes (RSMHA, F. 493, D. 9, C. 357, S. 351–352).

The situation with the Anatra factory in Simferopol and Matias factory in Berdiansk was typical for Russian; in 1916–1917 a range of enterprises received state subsidy and loans to expand plane production but there was a tiny effect. The possible course of action could be the establishment of State Aviation Factory. Another factor that made the Army do so was lack of interest of private entrepreneurs in implementation of improved planes samples. State factory had to make the implementation of new models playing the leading role in this field. The place for the factory had been chosen; it was Kherson in the South of Ukraine. The main reason of placing the factory there was good climate, mainly a lot of sunny days favorable for plane testing. On 31 March 1917 a final decision of building a State aviation factory in Kherson was made with the capacity of 200 planes per year with expense 3.35 million rubles; and an Aviation engine factory with capacity of 200 engines with total cost 3.4 million rubles (RSMHA, F. 493, D. 6, C. 11, S. 127). To control the building process a specialized Committee was established headed by Professor Aleksandr Van-Der-Flit. It was predicted in the plan that in July 1917 production of machine guns for planes will commence; at the end of 1917 – production of spare parts for planes and aviation engines, and till 1 July 1918 two factories will have been built. But building process was very slow and factories in Kherson were not in operation. Till January 1918 1.25 million rubles were given for the needs, 830 000 rubles out of which were spent to purchase building materials, tools, road building etc.) (RSMHA, F. 493, D. 6, C. 11, S. 171). Despite the expectation it turned out that the state was not a better and more effective manager of money than private owners. It is transparent that specifics of political situation should be taken into account – an effort to establish a center of aviation industry in Kherson coincided with revolutionary activities.

Production of aviation engines.

We have already mentioned one of the most serious problems for Russian aviation during the First World War period – chronic “engine hunger”. There was total dependence on the import of aviation engines until September 1913 when first factory of aviation engine of a Joint Stock Association Le Rhone started to function in Moscow. Inventive rotary engines were produced there with capacity 80–120 hp. Average month capacity of the factory in 1915 was 25 engines but in 1917 it increased up to 40 samples. Inventive rotary engines were also produced by Motor factory in Riga which were evacuated to Moscow just after the war began (Kulikov, 2014, p. 228).

In July 1915 a factory of Joint Stock Association Salmson was opened in Moscow (with French investment). In November a stacking of engines using imported details began there. Later some spare parts were produced in Moscow but using imported half-finished items. In total during the war period this enterprise produced approximately 400 engines. Small amount of aviation motors also was produced by Russian Renault factory and FRAA.

Trying to solve the problem of lack of aviation engines, Russian government started the broad development campaign in 1916. A range of companies got subsidies and loans to build new factories. Among them there were “veterans” of aviation industry as well as newcomers

One of the newcomers in this field was electro technical company Diuflon and Konstantinovich from Petrograd, known as Deka company. Having received government support this company established an office of aviation engines which was run by an engineer Nikolai Brillig. Trophy German 4-cylinder engines Mercedes liquid cooling served as a role model of products. The company received an order to produce five engines with capacity 100 hp, 50–129 hp and 180–168 hp for total cost more than 5.3 million rubles (RSMHA, F. 493, D. 4, C. 384, S. 102–103). Production of first engines began in Petrograd. On October, 12 1916 it was announced that the engine with capacity 100 hp. successfully completed testing. For mass engine production the company Deka bought a factory of agricultural vehicles which belonged to brothers Moznaim in Aleksandrovsk (now Zaporizhzhia) (RSMHA, F. 493, D. 4, C. 352, S. 2). After modernization this factory became one of the best equipped enterprise of aviation industry in Russia. But mass engine production was not even started. As to 13 Sep 1917 Deka factory produced only one engine with capacity 100 hp (RSMHA, F. 493, D. 11, C. 305, S. 44). The enterprise was behind the plan as 135 ordered engines out of 235 had to be produced till the end of 1916. Finally, Deka factory could not start the production of aviation engines until Russia withdrew from the war.

Anatra also tried to start the production of aviation engines. In July 1916 he signed an agreement with Main Military Technical Department that implied building of aviation motors factory in Simferopol till April 1917 with capacity of 300 engines per year. To fulfill this plan Anatra was given a subsidized loan for 400 thousand rubles. First order comprised 200 Hispano-Suiza engines with capacity 200 hp. and 20 000 rubles cost per one engine. The contract implied the delivery of all engines during the period May-December 1917 (RSMHA, F. 493, D. 11, C. 193, S. 13). But these plans were disrupted. Machine tools ordered by Anatra in France at the beginning of 1917 were delayed by French government for their needs (RSMHA, F. 493, D. 11, C. 779, S. 1). Only in May 1917 all the tools were forwarded to a representative of Anatra company in Paris. Artur Anatra proposed to use these machine tools for establishment a design office in Paris from where sets of spare parts should be delivered to Simferopol. But this idea faced skepticism from military personnel who thought that the war in the sea would not allow us to guarantee regular delivery from France. Delivery of machine tools to Simferopol delayed. According to the latest report dates 13 February 1918 none of the machine tools arrived to Simferopol; they were in Arkhangelsk (RSMHA, F. 493, D. 11, C. 779, S. 101). Because of revolutionary activities transportation of equipment became impossible and a factory of aviation engines in Simferopol did not start to operate.

None of the efforts to expand the production of aviation engines in Russia in 1916–1917 showed desired results. “Engine hunger” remained a total nightmare for Russian aviation: it is even enough to say that in 1917 Military Ministry ordered 2290 planes but received (including import) only 525 aviation engines (Kulikov, 2014, p. 229).

General characteristic of aviation industry.

During 1914–1917 3949 planes were produced in Russia. Is it many or a few? To compare let's admit that 36228 planes were produced in France, in Great Britain – 22747 plane, in Germany – 28185 (Soboliev, 2011, p. 18). Consequently, Russian aviation industry managed to produce fewer planes than any of the abovementioned country. More significant is the comparison of annual production. In 1914 Russian aviation industry produced 445 planes while German aviation industry produced 1348 planes, French – 541 planes, British – 245. In 1917 this number for Russia was 1432, for France – 23699, for Great Britain – 14421 (Soboliev, 2011, p. 30). It means that for the stated above period annual production in France increased in 44 times, in Germany – in 10,5 times, but in Russia – only in three times. Moreover, in 1917 plane production in Russia decreased in comparison with 1916, mainly 1386 planes in comparison with 1432. There are several reasons for that. First this was because of economic backwardness of the Russian Empire. In 1914 Russian was one the poorest country in Europe based on the GDP data (the situation was worse only in Portugal). Great Britain had bigger GDP, namely in 3.3 times, Germany – in 2.45 time, France – in 2.35 times. Besides, revolutionary activities in 1917 could not help industry to function in a sufficient manner. System of planes purchase based on standard costs, could not be flexible in the economic reality. From March to October 1917 purchase capability of rubles decreased in 4 times because of inflation, but purchase price for planes remained the same. As a result, for instance, Anatra complained about losing 6000 rubles per each Anasal plane production (Russian State Military Historical Archive. F. 493, D. 9, C. 56, S. 280). It is transparent that it could not attract companies to increase the amount of products.

Russian aviation industry characterized by its high concentration and by having a gap between big and small enterprises; there were no average companies. 90% of the production was provided by four big factories, namely Duks, Shchetinin, Anatra and Lebediev. Other 10% was divided between aviation office of FRAA (which produced mainly heavy planes but in small amount) and several small factories, or it is better to say workshops (Tereshchenko, Moska, Adamenko, Sliusarenko) (Soboliev, 2011, pp. 29–30).

Enterprises of Russian aviation industry differed greatly from European by low productivity and weak engineer cadres. Based on V. Savin's data, Anatra factory requires 30–40 employees to work during one month to construct one plane; meanwhile German and French factories required only 10 employees. There was one engineer per

50–100 employees in German factories, but in Russian factories, one engineer per 500–600 employees (Savin, 1995, p. 84).

Situation was critical at minor enterprises, for instance, there were no engineers at all at Adamenko factory. Consequently, such weakness of cadre potential had negative influence on the quality of products. Big enterprises such as Anatra and Matias could afford to compensate for the lack of domestic specialists inviting engineers from abroad. But for small enterprises it was not possible because of finance considerations – foreign specialists demanded for higher salary than Russians. Total quantity of workers in the Russian aviation factories increased from 1675 to 10800 people from 1914 to 1917 (Soboliev, 2011, p. 81). By this increase was followed by decrease of work productivity; as we mentioned before annual growth of planes production increased only in three times. “During the First World War, aircraft production was revived for obvious reasons, nevertheless, the domestic aircraft industry managed to meet only 9% of the demand for aircraft and 5% of the demand for engines generated by the Russian army in 1914–1917” (Mukhin, 2022, p. 60).

Being unable to provide the necessary quantity of planes led to great lack of planes in the front units. As to August, 2 1917 Corps Aviation squadrons` strength was only 42% (they lack 202 planes), Artillery Aviation squadrons` strength was 74%, Fighter Aviation squadrons` strength was 85%; and only Army Aviation squadrons almost met the plane requirements (Duz, 1989, pp. 195–196).

Conclusions.

Chronic lack of planes in Russian aviation was even greater from perspective of their low combat capabilities. Biplanes Farman and Voisin were main planes in army aviation in 1917. Their speed slightly exceeded 100 km/h and it was not enough. Moreover, these planes had pushing propeller that made them too sensitive for enemy attacks from the back. But utilization of Farman and Voisin planes continued and industry continued to receive orders for these planes. Other scout planes such as Lebed XII and Anade did not meet time requirement in summer 1917 despite their more modern design (construction). Bomber “Illia Muromets” considered to be the most popular plane of Russian design, underwent only small improvements during the war period which could not enhance its parameters. In 1917 flight capabilities of “Illia Muromets” were too low. Only at the end of 1917 one started licensed production of modern French biplanes SPAD VII.

To sum up, Russian aviation industry appeared to be unable to supply military planes of efficient quality and in required amount during the war. Most of the planes duplicated foreign samples. Even those projects which had been mentioned earlier were based on foreign projects (Lebed XII and Anade/Anasal adapted German constructions and aircrafts D. Hryhorovych’s based on French models). Such duplication led to the situation when Russian aviation was sad been applied by old-fashioned planes. Almost one year passed in-between the appearance of a new plane in France till it was produced in Russia. In IWW conditions this plane became old-fashioned very soon. As a result,

Russian military aviation could not compete with German and Austro-Hungarian aviation. Russian opponent in eastern front retained few planes which were old-fashioned. But most of modern materials were concentrated in western and Italian fronts.

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The authors declare no conflict of interest.

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Авіаційна промисловість Росії і виклики Першої світової війни

***Анотація.** Мета дослідження полягає у висвітленні особливостей розвитку авіаційної промисловості Російської імперії в роки Першої світової війни. Основна увага зосереджена на аналізі виробничих програм та відповідності їх кількісних і якісних параметрів вимогам війни. Методологія дослідження побудована на засадах історизму, наукової об'єктивності, системного підходу та систематизації даних. Задля досягнення поставленої мети автори використали низку загальнонаукових методів (аналіз, синтез, класифікація) та специфічних історичних методів, як-от проблемно-хронологічний, порівняльно-історичний, ретроспективний, періодизації. Автори дійшли висновку, що Перша світова війна стала нелегким випробуванням для російської промисловості, у тому числі авіаційної галузі, яка перебувала ще у стадії становлення. Потреби фронту вимагали значного зростання виробництва літаків, що за умов загальної економічної відсталості Росії було складним завданням. Авіаційна промисловість, представлена кількома великими (як на масштаби Росії) підприємствами, продемонструвала слабку динаміку зростання. За час війни річний обсяг випуску літаків в Росії зріс лише утричі, тоді як в Німеччині – в 10 разів, а у Франції та Великобританії це зростання було ще більшим. Провідні підприємства авіаційної промисловості – заводи Дукс, Лебедева, Анатра, Щетініна – вдавались, головним чином, до копіювання закордонних взірців (французьких, а іноді – німецьких). Спроби налагодити випуск оригінальних конструкцій виявились не надто вдалими. Найвідоміший приклад – бомбардувальник “Ілля Муромець”, який був передовим у 1914 р., але застарів до 1917 р. Вузьким місцем було і виробництво авіаційних двигунів, яке суттєво відставало від випуску літаків. Величезні інвестиції, зроблені у 1916–1917 рр. в розвиток існуючих і будівництво нових підприємств з випуску літаків та авіаційних двигунів, не дали результату: жоден з цих заводів так і не розпочав випуск продукції. Ми проаналізували деякі з цих невдалих спроб – будівництво авіаційних заводів Анатра в Сімферополі та Матіас в Бердянську,*

а також авіамоторних заводів Анатра в Сімферополі та Дека в Александровську. Державна політика регулювання авіаційної промисловості, яка полягала в наданні пільгових кредитів та субсидій, виявилась неефективною – її нівелювали стандартні закупівельні ціни, які не враховували чинник інфляції. Таким чином, російська авіаційна промисловість виявилась нездатною відповісти на виклики війни. У даній статті проаналізовано, як розвивались виробничі програми провідних російських авіаційних заводів, якими були кількісні та якісні параметри їхньої продукції.

Ключові слова: *авіаційна промисловість; авіаційний завод; військова авіація; військові літаки; Російська імперія; Перша світова війна*

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