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PREFACE

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

In the new issue, our scientific journal offers you thirteen scientific articles. As always, we try to offer a wide variety of topics and areas and follow current trends in the history of science and technology.

In the article by Olha Chumachenko, on the basis of a wide base of sources, the article highlights and analyzes the development of research work of aircraft engine companies in Zaporizhzhia during the 1970s. The existence of a single system of functioning of the Zaporizhzhia production association "Motorobudivnyk" (now the Public Joint Stock Company "Motor Sich") and the Zaporizhzhia Machine-Building Design Bureau "Progress" (now the State Enterprise "Ivchenko – Progress") has been taken into account.

Leonid Griffen and Nadiia Ryzheva present their vision of the essence of technology as a socio-historical phenomenon. The article reveals the authors' vision of the essence of the technology as a sociohistorical phenomenon. It is based on the idea that technology is not only a set of technical devices but a segment of the general system – a society – located between a social medium and its natural surroundings in the form of a peculiar social technosphere, which simultaneously separates and connects them.

Definitely the article by Denis Kislov, which examines the period from the end of the XVII century to the beginning of the XIX century, is also of interest, when on the basis of deep philosophical concepts, a new vision of the development of statehood and human values raised. At this time, a certain re-thinking of the management and communication ideas of Antiquity and the Renaissance took place, which outlined the main promising trends in the statehood evolution, which to one degree or another were embodied in practice in the 19th and 20th centuries. A systematic approach and a comparative analysis of the causes and consequences of those years' achievements for the present and the immediate future of the 21st century served as the methodological basis for a comprehensive review of the studies of that period.

The article by Serhii Paliienko is devoted to an exploration of archaeological theory issues at the Institute of archaeology AS UkrSSR in the 1960s. This period is one of the worst studied in the history of Soviet archaeology. But it was the time when in the USSR archaeological researches reached the summit, quantitative methods and methods of natural sciences were applied and interest in theoretical issues had grown in archaeology. Now there are a lot of publications dedicated to theoretical discussions between archaeologists from Leningrad but the same researches about Kyiv scholars are still unknown

The legacy of St. Luke in medical science, authors from Greece - this study aims to highlight key elements of the life of Valentyn Feliksovych Voino-Yasenetskyi and his scientific contribution to medicine.

Among the scientists of European greatness, who at the turn of the XIX and XX centuries showed interest to the folklore of Galicia (Halychyna) and Galician Ukrainians, contributed to their national and cultural revival, one of the leading places is occupied by the outstanding Ukrainian scientist Ivan Verkhratskyi. He was both naturalist and philologist, as well as folklorist and ethnographer, organizer of scientific work, publisher and popularizer of Ukrainian literature, translator, publicist and famous public figure. I. H. Verkhratskyi was also an outstanding researcher of plants and animals of Eastern Galicia, a connoisseur of insects, especially butterflies, the author of the first school textbooks on natural science written in Ukrainian.

A new emerging field that has seen the application of the drone technology is the healthcare sector. Over the years, the health sector has increasingly relied on the device for timely transportation of essential articles across the globe. Since its introduction in health, scholars have attempted to address the impact of drones on healthcare across Africa and the world at large. Among other things, it has been reported by scholars that the device has the ability to overcome the menace of weather constraints, inadequate personnel and inaccessible roads within the healthcare sector. This notwithstanding, data on drones and drone application in Ghana and her healthcare sector in particular appears to be little within the drone literature. Also, little attempt has been made by scholars to highlight the use of drones in African countries. By using a narrative review approach, the current study attempts to address the gap above. By this approach, a thorough literature search was performed to locate and assess scientific materials involving the application of drones in the military field and in the medical systems of Africans and Ghanaians in particular.

The paper by Artemii Bernatskyi and Vladyslav Khaskin is devoted to the analysis of the history of the laser creation as one of the greatest technical inventions of the 20th century. This paper focuses on establishing a relation between the periodization of the stages of creation and implementation of certain types of lasers, with their influence on the invention of certain types of equipment and industrial technologies for processing the materials, the development of certain branches of the economy, and scientific-technological progress as a whole. The paper discusses the stages of: invention of the first laser; creation of the first commercial lasers; development of the first applications of lasers in industrial technologies for processing the materials. Special attention is paid to the “patent wars” that accompanied different stages of the creation of lasers. A comparative analysis of the market development for laser technology from the stage of creation to the present has been carried out.

Nineteenth-century world exhibitions were platforms to demonstrate technical and technological changes that witnessed the modernization and industrialization of the world. World exhibitions have contributed to the promotion of new inventions and the popularization of already known, as well as the emergence of art objects of world importance. One of the most important world events at the turn of the century was the

1900 World's Fair in Paris. Thus, the author has tried to analyze the participation of representatives of the sugar industry in the World's Fair in 1900 and to define the role of exhibitions as indicators of economic development, to show the importance and influence of private entrepreneurs, especially from Ukraine, on the sugar industry and international contacts.

The article by Viktor Verhunov highlights the life and creative path of the outstanding domestic scientist, theorist, methodologist and practitioner of agricultural engineering K. G. Schindler, associated with the formation of agricultural mechanics in Ukraine. The methodological foundation of the research is the principles of historicism, scientific nature and objectivity in reproducing the phenomena of the past based on the complex use of general scientific, special, interdisciplinary methods. For the first time a number of documents from Russian and Ukrainian archives, which reflect some facts of the professional biography of the scientist, were introduced into scientific circulation.

The authors from Kremenchuk National University named after Mykhailo Ostrohradskyi presented a fascinating study of a bayonet fragment with severe damages of metal found in the city Kremenchuk (Ukraine) in one of the canals on the outskirts of the city, near the Dnipro River. Theoretical research to study blade weapons of the World War I period and the typology of the bayonets of that period, which made it possible to put forward an assumption about the possible identification of the object as a modified bayonet to the Mauser rifle has been carried out. Metal science expert examination was based on X-ray fluorescence spectrometry to determine the concentration of elements in the sample from the cleaned part of the blade.

In the article by Mykola Ruban and Vadym Ponomarenko on the basis of the complex analysis of sources and scientific literature the attempt to investigate historical circumstances of development and construction of shunting electric locomotives at the Dnipropetrovsk electric locomotive plant has been made.

The next scientific article continues the series of publications devoted to the assessment of activities of the heads of the Ministry of Railways of the Russian Empire. In this article, the authors have attempted to systematize and analyze historical data on the activities of Klavdii Semyonovych Nemeshaev as the Minister of Railways of the Russian Empire. The article also assesses the development and construction of railway network in the Russian Empire during Nemeshaev's office, in particular, of the Amur Line and Moscow Encircle Railway, as well as the increase in the capacity of the Trans-Siberian Railway. The article discusses K. S. Nemeshaev's contribution to the development of technology and the introduction of a new type of freight steam locomotive for state-owned railways.

We hope that everyone will find interesting useful information in the new issue. And, of course, we welcome your new submissions.

HISTORY OF SCIENCE

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Scientific and research work of Zaporizhzhia aircraft engine builders in the 1970's

Abstract. *On the basis of a wide base of sources, the article highlights and analyzes the development of research work of aircraft engine companies in Zaporizhzhia during the 1970s. The existence of a single system of functioning of the Zaporizhzhia production association "Motorobudivnyk" (now the Public Joint Stock Company "Motor Sich") and the Zaporizhzhia Machine-Building Design Bureau "Progress" (now the State Enterprise "Ivchenko – Progress") is taken into account. The directions of research work that were peculiar to the specified period are established. These were inventive activities, development of technological processes, increasing the reliability and durability of gas turbine engines, automation and mechanization of production, cooperation with industry firms in other countries, and cooperation with research institutions. The development of a scientific-theoretical and technical basis for the production of aircraft engines is comprehensively assessed. Its dependence on structural subdivisions, which at the aircraft engine enterprises were the department of scientific and technical information, the Information and Computing Center, the department of patenting, innovation and invention of the plant, was determined. They were engaged in the accumulation, generalization and dissemination among specialists of their own and borrowed experience of both past and present. The activity of the scientific and technical council, which included leading specialists of Zaporizhia aircraft engine companies, was monitored. Factors that contributed to the revival of research in the second half of the 1970's were identified. Among them, the leading place belongs to the creation and production of D-36 and D-18T aircraft engines. The design advantages of these engines are described. Some shortcomings and miscalculations made during their design are taken into account. Methods and measures aimed at overcoming the difficulties associated with the design, manufacture, operation and repair of aircraft engines are summarized. The research is based on the*

following methods: actualization, comparative-historical, problem-chronological, multifactor analysis, principles of historicism and objectivity.

Keywords: *research work; aircraft engine industry; gas turbine engine; Zaporizhzhia Machine-Building Design Bureau; Zaporizhzhia Production Association*

Introduction.

Specialists in the aviation industry have been continuously raising the technological level of the industry for many decades, which is impossible without research work. Ukraine is the country that has a full cycle of design, manufacture, operation and repair of aircraft. Today, the only aircraft engine capacities in Ukraine are "Motor Sich" Public Joint Stock Company and "Ivchenko-Progress" State Enterprise, which compete with such well-known companies as "General Electric", "Pratt and Whitney" (USA), and "Rolls-Royce" (UK) and "Snecma" (France). It should be noted that the main specificity of the preparation of aircraft engines is the need to combine production, research and implementation of new technologies. Zaporizhzhia aircraft engine builders have been carrying out purposeful work on putting the latest technologies into production for several decades (Boguslaev, Mozgovoj, Balushok, & Reuchenko, 2010, p. 9). The country, which has its own powerful aviation scientific developments, is able to dynamically increase national achievements, provide the market with the latest technologies and employ qualified specialists. Thus, the study of ways to implement research and production work of specialists in the field of aircraft engine construction in the 1970s are relevant in today's realities.

The subject of the study is to some extent covered in the works of the Soviet and modern periods. They mainly concern the history of "Motor Sich". They cover the ways of development and serial production of aircraft engines, from the piston to modern gas turbine engines. These are materials about aircraft on which engines were installed in different periods of the plant's formation. The works assess the contribution of specialists whose work has become a decisive factor in the development of aircraft engine company (Boguslaev & Zhemanyuk, 2000; Boguslaev, Zhemanyuk, & Malysh 2014; Koval' & Filon, 1986). The long-term relationship of Motor Sich with research and development bureaus and research institutes is reflected in the popular science publication of the enterprise (Boguslaev et al., 2001). At the same time, research activities are represented by single studies on the cooperation of Zaporizhzhia aircraft engine companies with leading scientists of Ukraine in the field of dynamic strength (Larin & Chumachenko, 2016). Some information about the mechanization and automation of production at the enterprise is contained in the articles of the daily multi-volume edition of the aircraft engine plant (Kudrya, 1972; Kry`lov, 1973).

The proposed study is based on archival documents of the State Archives of Zaporizhia region, the Central State Archive of Public Associations of Ukraine and materials of the Museum of History "Motor Sich" (Derzhavnyi arkhiv Zaporizkoi

oblasti; Muzej tekhniki "Motor Sich"; Tsentralnyi derzhavnyi arkhiv hromadskykh obiednan Ukrainy).

The purpose of the study is determined in accordance with the relevance of the chosen topic and is a comprehensive study and historical reconstruction of the development of research activities of aircraft engine companies in Zaporizhzhia during the 1970s.

Research methods.

The research is based on the following methods: actualization - the connection of the subject of work with the present is established; comparative-historical - determined the patterns of implementation of established areas of research activities in the workplace; problem-chronological - traced qualitative and quantitative changes in the structure of Zaporizhzhia aircraft engine companies as a result of inventive work; multifactor analysis - identified factors that influenced the revival of scientific and technical support of the studied enterprises; principles of historicism and objectivity - a concrete-historical approach is formed and the cooperation of Zaporizhzhia aircraft engine builders with foreign countries and research institutions of the USSR is reflected. This approach made it possible to fully reveal the features of development and interaction of research and production activities at the enterprises of the aircraft engine industry in Zaporizhzhia.

Results and discussion.

Research work was carried out at various levels of the Zaporizhzhia aircraft engine company, which in 1971 was reorganized into the Zaporizhzhia production association "Motorobudivnik". V. Omelchenko remained the director for more than a decade (Fig. 1). In the same year, the physical laboratory of the plant, represented by a team consisting of V. Bondarenko, G. Bondarenko and S. Masya, developed a thickness gauge VTP-3f. He measured the thickness of the layer of cadmium, chromium, copper and other coatings of parts (STI. Pnevmaticheskoe prisposoblenie, 1971, p. 3). In turn, the designer of the Department of Mechanization and Automation O. Vasyliuk developed a pneumatic brand, which was used to apply the brand to various parts by the individual impact of the device (STI. Pnevmaticheskij klejmitel`, 1971, p. 3).

Simultaneously, the chief designer of the Zaporizhzhia engine design bureau "Progress" V. Lotarev without the defense of the dissertation was awarded the degree of Doctor of Technical Sciences (Fig. 2). Thus, his significant contribution to the development of the Soviet aircraft engine industry and the aviation industry, in general, was confirmed. Under his leadership, scientific work was carried out to develop a family of turboprop engines AI-20 and AI-24. In addition, he led the design work to create a dual-circuit turbojet engine AI-25 (DAZO. F. R-5444. S. 1. F. 136. p. 1).

a *b*

Figure 1. General Director of the Zaporizhia Production Association "Motorobudivnyk" (1971–1988) *(a)*; The central checkpoint of the "Motor Sich" enterprise, decorated with a smaller model of the Kudashev-1 biplane *(b)* (Boguslaev & Zhemanyuk, 2000).

Recognized designer-scientist received the right to run as a corresponding member of the Academy of Sciences of the USSR Department of Mathematics, Mechanics and Cybernetics, specialty – "Mechanics" (DAZO. F. R-5444. S. 1. F. 136. p. 2).

a *b*

Figure 2. Chief Designer (1963–1968; 1968–1981) General Designer of the Zaporizhia Machine-Building Design Bureau "Progress" (1981–1989) *(a)*; the building of the central building "Ivchenko-Progress" today *(b)* (Ivchenko, 2014, p. 9).

In 1972, public patent-inventive and public design bureaus were established on the basis of the leading departments of the Zaporizhzhia Production Association. Among the tasks of organizations, the main place was occupied by technical assistance to innovators and inventors during the development and implementation of their innovations and inventions (DAZO. F. R-171. S. 5. F. 470. p. 4). Specialists of the

bureau developed a regulation on the examination of inventions, which was approved by the management of the enterprise. All documentation was sent to the Committee for Inventions and Discoveries under the Council of Ministers of the USSR. Within five years, a research team was formed, which was engaged in inventive activities (G. Dubrov, O. Mamay, A. Shabotenko, V. Konstantinovsky, A. Reitman, O. Krasnikov, P. Bakshi and G. Kudrychenko) (Kudrya, 1972, p. 1).

From 1970 to 1972, specialists of the Zaporizhzhia Engine Design Bureau "Progress" invented a method of surface hardening of parts using powerful ultrasound and designed a device for its implementation. Since 1973, the research staff of the bureau has cooperated with the Zaporizhzhia Production Association "Motorobudivnyk" and the Research Institute to improve and implement the developed technology in the industry. The main goal was to increase the strength and reliability of the operation of parts of gas turbine engines. The technology of surface plastic deformation developed by Zaporizhzhia scientists was introduced into the production of enterprises of the Ministry of Aviation Industry, the Ministry of Civil Aviation and the Ministry of Energy Turbobuilding. This innovation has increased the productivity and quality of machining of parts by 10 times.

In 1974, the Zaporizhzhia plant began scientific and technical cooperation with many countries (DAZO. F. R-5705. S. 2. F. 10. p. 9). Joint work was established with enterprises in the United States, England, France, the German Democratic Republic, the Federal Republic of Germany, the Czechoslovak Socialist Republic, the Polish People's Republic, Italy, and Sweden. Already in 1975, the plant introduced some leading technologies. Cutters made of elbor-P, hexanite-P and other super hard materials based on boron nitride were used. They began to manufacture blanks and parts by the method of precise volumetric stamping, introduced electrochemical, electro erosion, ultrasonic, electron beam and light dimensional processing. In addition, the following welding processes were used: plasma, radiofrequency, electric beam, ultrasonic, diffusion and light beam, and explosion welding (DAZO. F. R-5444. S. 1. F. 296. p. 18).

An Information and Computing Center headed by V. Korotenko was opened at the enterprise. Accordingly, they increased the production area, for the purchase of which they purchased electronic equipment. For example, the new electronic computer "Minsk-22" performed 5–6 thousand operations per second. In 1974, a more progressive model was mastered – "Minsk-32", which performed more than 30 thousand operations (Kry`lov, 1973, p. 1).

The exchange of scientific and technical information accelerated the work of employees of the Department of Scientific and Technical Information, which was an independent structural unit of the plant. (DAZO. F. R-5705. S. 2. F. 15. p. 2). In order to gain technical experience and implement it in production in 1976, cooperation with foreign companies has significantly intensified. An information-analytical group was opened, the main task of which was to visit foreign companies and summarize the

obtained information. The chief engineer of the plant V. Kramny was elected the head (DAZO. F. R-5705. S. 2. F. 50. p. 1).

At the same time, the procedure for transferring the results of scientific research, invented samples of new types of materials and advanced technological solutions introduced into production to the aviation industry was regulated. Among these, the most effective were the installation for the separation of rods of cast blades in alkaline solution, the machine for feeding springs and the installation for splitting air to produce inert gases, nitrogen and oxygen. Relevant documentation on the latest achievements was systematically published in the monthly collection "Operational Information" (DAZO. F. R-5705. S. 2. F. 148. p. 3–11).

Thus, the plant was equipped with 751 units of automatic and semi-automatic equipment, including installations with software and numerical software control. The first research device of the reserve peak turbocharger TKU-400, which was constructed on the basis of an aircraft engine, was developed at the engine plant. At the same time, the technologists designed a device for processing the air assembly of the front crankcase of aircraft engines. Its application facilitated the process and transferred the work to the milling machine (DAZO. F. R-5705. S. 2. F. 59. pp. 2–7). The author's team consisting of O. Volkov, A. Peremylovsky and P. Fuchadzhi invented a method of restoring the compressor blades. It allowed updating the details rejected owing to erosion wear (DAZO. F. R-5705. S. 2. F. 69. p. 4). Introduced some new technologies that made it possible to repair the nozzle devices of the auxiliary engine AI-9. They consisted of replacing a cast diaphragm made of sheet metal and using extrusion blanks for precision stamping. The result of such innovations was a saving of 369 thousand rubles (DAZO. F. R-5705. S. 2. F. 76. p. 1).

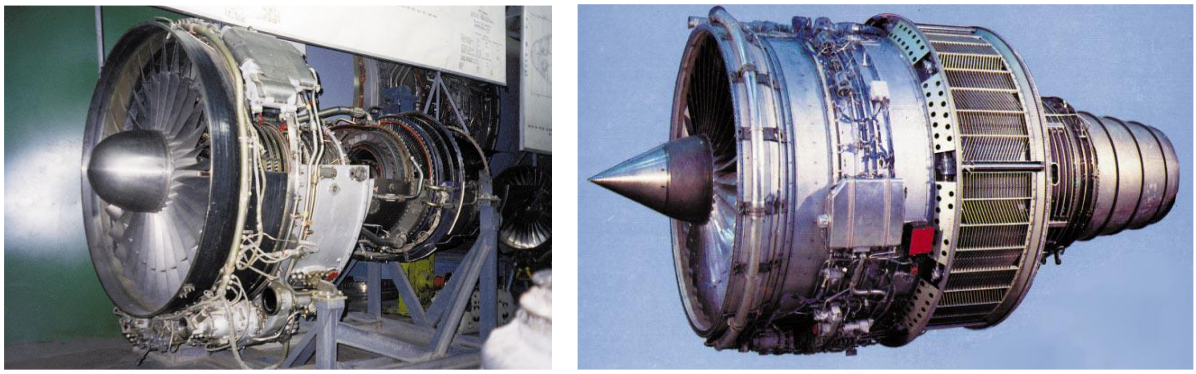
In 1976, at a meeting of the Scientific and Technical Council of the company, the developers presented the work that was nominated for the State Prize – "Creation, implementation in serial production, and operation of passenger aircraft An-24, its variants and modifications". The team of authors included Deputy Chief Designer of the Zaporizhzhia Bureau "Progress", Candidate of Technical Sciences V. Chuyko. As a result of his scientific and research activities, an automatic launch system was tested and put into serial production. It was carried out when using high voltage to power the starting equipment. This allowed to obtain high system parameters and ensure reliable engine start in all operating conditions (DAZO. F. R-5444. S. 1. F. 211. pp. 1–4).

The work of the department of patenting, innovation, and invention of the plant continued. In 1979, 10 copyright certificates were issued. Thus, the proposal of A. Zhurbin, O. Sidun, and O. Pedan was to change the design of the container for hardening carbon molds. This significantly reduced electricity costs and increased productivity at the plant (DAZO. F. R-5705. S. 2. F. 91. p. 6).

At the end of the 1970s, research work was revived due to the creation and production of D-36 and D-18T aircraft engines (Fig. 3).

Thus, serial production of the D-36 engine began in 1977. At that time, its warranty life was 300 hours, which was not enough. Specialists of the chief designer's

department have started research work aimed at increasing engine power. As a result, the author's team consisting of I. Berim, B. Kovaltsov, V. Lviv, G. Taran, F. Arslanov and O. Rakitin managed to increase the reliability of important engine components (compressor, turbine, combustion chamber, etc.). As a result, the warranty life of the engine reached 9 thousand hours. A large set of design and research works was carried out to increase the fuel efficiency of the engine, which reduced the specific fuel consumption on takeoff - from 0.375 to 0358 kg/kgf (Boguslaev & Zhemanyuk, 2000, p. 97).



a *b*

Figure 3. Aviation turbojet engine D-36 *(a)*;
Aviation turbojet engine D-18T *(b)* (Boguslaev & Zhemanyuk, 2000).

In its final form, the D-36 was a complex structure with the sixth degree of double-circuit on takeoff mode. The engine is made of a long-term system with an annular combustion chamber, axial 14-stage compressor, five-stage turbine and intermediate housing. In the standard version, its takeoff mode was 6500 kgf, and the mass was 1100 kg (Muzej tekhniki "Motor Sich". F. IX. F. 1556. p. 1). In order to increase the reliability of the engine, the design team conducted a number of technological measures. Among them, a significant place was occupied by the introduction of the casting of nozzles and turbine blades on smelted models. There was no allowance for machining of the profile. This solution made it possible to reduce the complexity of the engine kit by 800 hours. Another invented technical measure of electron beam welding has reduced the weight of the engine and reduced the use of metal in the manufacture of compressor rotors for it (TsDAHOU. F. 1. S. 25. F. 710. p. 148).

Note that work on the design of the D-36 engine lasted several years. It was necessary to eliminate all the shortcomings and miscalculations that are possible at the stage of design and manufacture of parts of the prototype. That is why a meeting was held with the participation of representatives of the Central Institute of Aviation Engine Building, the All-Union Institute of Aviation Materials, and the Zaporizhzhia Machine-Building Design Bureau "Progress". It discussed the possible causes of the destruction of the rotor shell of the high-pressure compressor of the D-36 engine. Thus, it was found that the reason was a decrease in the strength and ductility of the alloy VT-9 in those places where there was contact with the molten refractory material. In addition,

the complication was the effect of operating voltage and temperature on the material. As a result of the discussion, it was decided to develop technological measures that will further prevent a similar situation (DAZO. F. R-5444. S. 1. F. 149. p. 19).

At the same time, under the leadership of O. Antonov, an operational-strategic aircraft An-124 "Ruslan" was created, which bypassed the American competitor Lockheed S-5A "Galaxy" (Zayarin, 1992, p. 8). The Ministry of Aviation Industry commissioned the Zaporizhia Machine-Building Design Bureau "Progress", headed by V. Lotarev, to design the engine for this aircraft. The design documentation of the components and systems of the engine, named D-18T, was mainly completed in 1977. The first batch of D-18T was created as a result of joint work with the Production Association "Motorobudivnyk", which later engaged in serial production of the engine (Muzej tekhniki "Motor Sich". F. IX. F. 1556. p. 7)

The D-18T engine, like its predecessor D-36, was made according to a long scheme. It was equipped with a thrust reversing device. The structure was a system of cascades with gas-dynamic connections between them. The fan stage consisted of a single-stage fan and a four-stage turbine. The medium pressure cascade had a seven-stage turbine. The next stage (high pressure) is a seven-stage axial compressor and a single-stage turbine. Each of the presented cascades was installed on only two supports. In all respects, the D-18T engine was at the level of the best world models. Yes, it was not inferior to the English engine RB.211 company "Rolls-Royce". More than 40 original technical solutions used in the design of engine components and parts, made at the level of inventions and protected by the copyright of the USSR (Boguslaev & Zhemanyuk, 2000, p 101).

Significant assistance in resolving scientific and technological issues came from specialists of research institutes. Thus, cooperation with the Institute of Problems of Materials Science has solved the problem of using high-strength steel in the construction of a new engine. The director of the institution, academician, doctor of physical and mathematical sciences V. Trofimov formed an experimental collaboration with the National Institute of Aviation Technologies, the Institute of Non-Metallic Materials, the Institute of Metal Physics, and the Academy of Sciences of the USSR. Based on the methods invented by the academician, new heat treatment technologies were developed. As a result of their introduction, Zaporizhzhia aircraft engine builders managed to overcome the problems that arose during the production of the D-18T engine (DAZO. F. R-5444. S. 1. F. 261. pp. 1–15).

In general, Zaporizhzhia aircraft engine builders established cooperation with many scientific organizations of the USSR. Among them, an important place was occupied by Zaporizhia Machine-Building Institute, Dnipropetrovsk Institute of Chemical Technology, Dnipropetrovsk Metallurgical Institute, Kharkiv Polytechnic Institute, Kharkiv Aviation Institute, Ukrainian Research Institute of Special Steel, State Research Institute of Plastics, Research Institute of Operation and Repair of Air Force Equipment, National Institute of Aviation Technologies, Central Research

Institute Institute of Heavy Engineering, State Research Institute of Civil Aviation, etc. (Koval' & Filon, 1986, p. 71; Boguslaev et al., 2001, p. 221).

In 1978, at a meeting of the Scientific and Technical Council heard a report made by M. Tsofin on the topic: "Study of the reliability of aircraft gas turbine engines in maintenance". The method of engine maintenance was one of the main gaps in the 1970s. Solving this problem should have significantly increased the efficiency of aircraft engines. One of the key aspects of the method was considered in M. Tsofin's research. Based on the materials of the Zaporizhzhia Machine-Building Design Bureau "Progress", the author reflected the process of creation and mass operation in civil aviation engines (AI-20, AI-24, AI-25). Existing methods of ensuring the reliability of the gas turbine engine of modular design D-36 were also involved. As a result of the study, a method was proposed for the gradual increase of the permitted operating time of aircraft engines based on the results of their operation (DAZO. F. R-5444. S. 1. F. 247. p. 12).

In the late 1970s, the company implemented the task of designing drawings of blade stamps and their manufacture. To overcome the problem of end-to-end transmission of a large amount of information on machine media developed by the Zaporizhzhia Design Bureau to machines with numerical program control at the plant created a system "Stamp". In addition, Zaporizhzhia aircraft engine builders have improved the quality of materials used for next-generation aircraft engines. The consequence of this was the introduction of carbon fiber-reinforced fan housing for D- 36 and D-18T engines (K novy`m sversheniyam gotovy`, 2008, p. 3).

In accordance with the national instructions for research, in 1979 the company set up a commission to inspect secret cases and documentation. She considered the achievements of the author's team of specialists, which included P. Zima, V. Omelchenko, A. Roitman, V. Tomila, G. Shentyabin and S. Rzhavin. Many years of work "Development, research, and implementation of methods for diagnosing and improving the vibration reliability of aircraft gas turbine engines" was nominated for the State Prize, so it was considered urgent to check its effectiveness by the newly established commission. The practical application of the invention has increased the budget of the enterprise by 14, 6 million rubles. (DAZO. F. R-5705. S. 2. F. 115. p. 4).

The study was classified as a top-secret due to a number of issues covered in it. The authors analyzed the defects of engines AI-24, AI-20M, TV3-117 and proved their direct impact on the destruction of engines, which led to plane crashes. In addition, the methods developed by the authors of vibration diagnostics of aircraft engines were introduced at the Zaporizhzhia Production Association. At the same time, the researchers found patterns of damage to the engine blades during operation. They developed a method for predicting the durability of the blades of gas turbine engines AI-20, AI-25 and AI-25TL. This significantly reduced the testing time of the blades to establish their operational reliability. Scientists have proposed new methods for determining the characteristics of oscillations that occur in engines. For the first time, new construction materials and structural details were used. Based on the study,

recommendations were formed, which were used to increase the vibration reliability of the blades of AI-20D, AI-20M, AI-25 and AI-25TL engines. The study submitted to the Secret Investigation Commission was of great importance for the aviation industry of the Soviet Union, as defects in the strength of gas turbine engines were one of the greatest threats of malfunction during their operation (DAZO. F. R-5705. S. 2. F. 115. pp. 10–11).

Conclusions.

Thus, the Zaporizhzhia Production Association "Motorobudivnyk" under the long-term leadership of V. Omelchenko and the Zaporizhzhia Machine-Building Design Bureau "Progress", which was headed by V. Lotarev during the period under study, continued close cooperation. Research work at Zaporizhzhia aircraft engine companies in the 1970 s underwent qualitative and quantitative changes. It is necessary to highlight the main vectors to which it was directed. Thus, the inventive activity was separated into an independent system, in which the key place was occupied by the formed team of authors. Public patent-inventive and public design bureaus were established, whose specialists developed regulations on the examination of inventions. The second area of research was to develop technological processes that could improve the level of production. The next vector is research activities aimed at improving the reliability and durability of gas turbine engines. Some projects developed by Zaporizhzhia scientists were implemented by the Ministry of Aviation Industry, the Ministry of Civil Aviation, and the Ministry of Energy Turbobuilding. To ensure the confidentiality of information at the company created a commission to verify cases and documentation. The fourth direction was the comprehensive automation and mechanization of enterprises. An information and computer center was opened at the plant. For a long time there was a Department of Scientific and Technical Information, which was a separate structural unit. The fifth vector was to establish scientific and technical cooperation of Zaporizhzhia aircraft engine builders with other countries. An information-analytical group was created, the main task of which was to visit foreign companies and summarize the information obtained. Finally, the sixth direction concerned the interaction with research institutions, collaboration with which allowed to perform tasks, the solution of which would be impossible without the intervention of industry scientists. At the end of the 1970s, research was revived thanks to the creation and production of D-36 and D-18T aircraft engines, the latter of which was not inferior to the English-made RB.211 engine from "Rolls-Royce".

It is known that the scientific and technical potential of any field of activity is the basis for ensuring the quality production of final products. The aviation industry is no exception - it is an industry that is constantly improving its technological level and gives a powerful impetus to the development of other areas of the economic sector. Taking into account all the achievements and miscalculations of the previous decades, during which the formation of the Ukrainian aircraft engine industry took place, it is possible to make significant profits and become a competitive state in the current

geopolitical situation. Such research helps to understand the existing problems and find ways to solve them.

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Науково-дослідна робота запорізьких авіадвигунобудівників у 1970-х роках

Анотація. *У статті на основі широкої бази джерел висвітлено та проаналізовано розвиток науково-дослідної робота авіадвигунобудівних підприємств м. Запоріжжя протягом 1970-х рр. Враховано існування єдиної системи функціювання Запорізького виробничого об’єднання “Моторобудівник” (нині Публічне акціонерне товариство “Мотор Січ”) та Запорізького машинобудівного конструкторського бюро “Прогрес” (на сьогодні Державне підприємство “Івченко-Прогрес”). Встановлені напрями науково-дослідної роботи, які були властиві зазначеному періоду. Такими виявилися винахідницька діяльність, розроблення технологічних процесів, підвищення надійності та міцності газотурбінних двигунів, автоматизація та механізація виробництва, співпраця з галузевими фірмами інших країн та взаємодія з науково-дослідними установами. Комплексно оцінено розвиток науково-теоретичного та технічного підґрунтя виробництва авіаційних двигунів. Визначено його залежність від структурних підрозділів, якими на авіадвигунобудівних підприємствах були відділ науково-технічної інформації, Інформаційно-обчислювальний центр, відділ патентування, раціоналізаторства та винахідництва заводу. Вони займалися накопиченням, узагальненням та розповсюдженням серед спеціалістів власного та запозиченого досвіду як минулих років, так і сучасності. Відстежено діяльність науково-технічної ради, до складу якої входили провідні спеціалісти запорізьких авіадвигунобудівних підприємств. Виявлено фактори, які сприяли пожвавленню науково-дослідної діяльності в другій половині 1970-х рр. Серед них провідне місце належить створенню та виробництву авіаційних двигунів Д-36 та Д-18Т. Охарактеризовано конструкторські переваги зазначених двигунів. Враховано окремі недоліки та прорахунки, допущені під час їх проєктування. Узагальнено методи та заходи, спрямовані на подолання труднощів, пов’язаних із конструюванням, виробництвом, експлуатацією та ремонтуванням авіаційних двигунів. Дослідження базується на таких методах: актуалізації, порівняльно-історичному, проблемно-хронологічному, багатофакторного аналізу, принципів історизму та об’єктивності.*

Ключові слова: *науково-дослідна робота; галузь авіадвигунобудування; газотурбінний двигун; Запорізьке машинобудівне конструкторське бюро; Запорізьке виробниче об’єднання*

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Научно-исследовательская работа запорожских авиадвигателестроителей в 1970-х годах

Аннотация. *В статье на основе широкой базы источников раскрыты и проанализированы развитие научно-исследовательской работы авиадвигателестроительных предприятий г. Запорожья в период 1970-х гг. Учтено существование единой системы функционирования Запорожского производственного объединения “Моторостроитель” (ныне Публичное акционерное общество “Мотор Сич”) и Запорожского машиностроительного конструкторского бюро «Прогресс» (в настоящее время Государственное предприятие “Ивченко-Прогресс”). Установлены направления научно-исследовательской работы, присущей в указанный период. Такими являются изобретательская деятельность, разработка технологических процессов, повышение надежности и прочности газотурбинных двигателей, автоматизация и механизация производства, сотрудничество с отраслевыми фирмами других стран и взаимодействие с научно-исследовательскими учреждениями. Комплексно оценено развитие научно-теоретической и технической базы производства авиационных двигателей. Определена его зависимость от структурных подразделений, которыми на авиадвигателестроительных предприятиях были отдел научно-технической информации, Информационно-вычислительный центр, отдел патентования, рационализаторства и изобретательства завода. Они занимались накоплением, обобщением и распространением среди специалистов собственного и заимствованного опыта как прошлых лет, так и современности. Отслежена деятельность научно-технического совета, в состав которого входили ведущие специалисты запорожских авиадвигателестроительных предприятий. Выявлены факторы, которые способствовали оживлению научно-исследовательской деятельности во второй половине 1970-х гг. Среди них ведущее место принадлежит созданию и производству авиационных двигателей Д-36 и Д-18Т. Охарактеризованы конструкторские преимущества указанных двигателей. Учтены отдельные недостатки и просчеты, допущенные при их проектировании. Обобщены методы и меры, направленные на преодоление трудностей, связанных с конструированием, производством, эксплуатацией и ремонтом авиационных двигателей. Исследование базируется на таких методах: актуализации, сравнительно-историческому, проблемно-хронологическом, многофакторного анализа, принципов историзма и объективности.*

Ключевые слова: *научно-исследовательская работа; отрасль авиационных двигателей; газотурбинный двигатель; Запорожское машиностроительное конструкторское бюро; Запорожское производственное объединение*

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Technology as a socio-historical phenomenon

Abstract. *The article reveals the authors' vision of the essence of the technology as a sociohistorical phenomenon. It is based on the idea that technology is not only a set of technical devices but a segment of the general system – a society – located between a social medium and its natural surroundings in the form of a peculiar social technosphere, which simultaneously separates and connects them. The main objective purpose of the technosphere is to promote the effective rendering of society-generated entropy outwards; it defines the features of the technosphere as a sociohistorical phenomenon. The analogues of such material formations take place also in wildlife (from the spider-web to the beaver dam) but are very few and arise from the implementation of instinctive programs of the species. In a person's consciousness, such programmes are not given by "nature", they are formed on the basis of "desobjectivation" of technical objects available in society. In the process of "desobjectivation" the essence, the "logic of the subject" becomes the achievement of a person and due to his abilities is filled with new meaning. As a result, the technology is a materially ideal phenomenon: on the one hand, it is a set of technical objects and on the other hand – technical thinking of a person, the highest manifestation of which is technical sciences nowadays. Properly technical objects are created by society to meet the individual and social needs of a person. These are primarily consumption items; due to their manmade nature, the question of production means development arises, which over time becomes increasingly important, especially by virtue of their significant impact on social relations (which in time also require certain technical devices for their implementation). The complex of these devices forms the techno sphere of society as a compound integrity. Not only groups of different in application technical objects become the constituent parts of the technosphere, but also*

their conglomerates designed to perform certain functions, which, similar to the biological branch, were called techno enosis; in the latter at the account of a peculiar "competition", the development of these components in particular and the technosphere integrally takes place. However, despite consistency, the technosphere is a subsystem of a society, therefore, there is no perspective of creating certain laws of its development and an appropriate coherent periodization. For this reason, the scientific periodization of the development of technology as such is connected with the purpose of the given research and is defined by it.

Keywords: *technology; technosphere; technical thinking; technical devices; technocenosis*

Introduction: problem statement.

At the present stage of human civilization, the development of the general changes in social realities occurs very quickly. One of its *most important* factors is the rapid development of technology. Its study and successful interpolation will determine the possibility of the scientific forecast of the influence of technology on the course of iconic processes in society for the near future and will allow improving the conditions of scientific prediction of the technology impact on future social processes. The implementation of this task requires the definition of the essence of technology as a social phenomenon. The researchers have studied this question for a while and still, there are many different perspectives. This problem is studied as by Ukrainian (Vynnyk, 2016; Melnyk, 2010; Mykhailovskyi, 2018; Muratova, 2019; Chornomordenko & Kachak, 2016; Chursinova, 2014), so foreign (McLain, Irving-Bell, Wooff, & Morrison-Love, 2019; Nishimura, Kanoshima, & Kono, 2019; Kahlau, Schneider, & Souza-Lima, 2019; Oliveira, 2020; Ushakov, 2017; Jaspers, 2012) researchers. Consider the existence of different points of view on a set of defined issues.

The purpose of the proposed article is to present an original vision of the specified subject. The accents defined by us seem to be the most approximate to understanding the profound realities of technology as a social phenomenon.

The methods of research are chosen on the basis of historical scientific reliability of technical progress, special methods of technology development processes research. The article is based on scientific, theoretically-critical use of the previous research on the history of technology.

Results and discussions.

The technology is one of the most important social phenomena and as such deserves close attention. The research of technology as a specific phenomenon presupposes the starting of its definition, though there are lots of them nowadays. Basically, four interpretations of this phenomenon essence are defined, in particular: technology as a tool for work, as a system of artificial bodies of activity, as a public material system, as organized by man substance and energy. The analysis of dozens of

technology definitions indicates the absence of an expanded definition of the term that would cover all the features of the phenomenon. They either do not include all its manifestations (based mainly on the means of production), or do not sufficiently take into consideration its social nature. It is thought that the comprehension of this social phenomenon should begin with the analysis of society as a system (Kahlau, Schneider, & Souza-Lima, 2019; Nishimura, Kanoshima, & Kono, 2019).

According to the generalized by us scientific and theoretical ideas, the development of complex systems (in particular, living ones) provides for their constant complication with carrying out entropy to the external environment. The passage of junction points is followed by the transition to a higher structural level of development, the highest of which is society as a specific biological superorganism. In the process of such development, the role of the appearance of specific material formations, which the "living system" places between itself and the environment, is rather important. Thus, in the animal world, gradually complicated individual material objects – a kind of "proto-technology" (from the spider-web to the beaver dam) are observed (Frojde, 1986, p. 17; Rukovskij, 1991, p. 41) and in the public body, they form the technology as a necessary subsystem of the latter.

The creation of the marked objects in wildlife takes place as an external implementation of instinctive programs with the gradual (in the process of evolutionary development) inclusion of their correction elements on the basis of individual experience. In the society whose constituents (separate individuals) do not possess such a "program" from birth, it is formed in the consciousness of the latter as a "desobjectivation" of external objects of a technology previously created by humans. Then these programs, in their turn, are "objectificated" in human activities, in particular by creating new technical objects that society places between itself and the environment. A unique algorithm is formed: "the technology manifests itself as an active capability and power inherent not only to a separate person but to a person as a social creature and, ultimately, to humanity as a whole" (Aliyeva, 2003).

Consequently, the technology constitutes a social subsystem that forms a technosphere between society and the environment. It is formed by society, but from the materials and by the rules of nature, being a natural anthropogenic formation. The technosphere is the realization of people's activities, in particular their thinking, throughout history, and this world is objectificated – realized in the product – thinking of mankind, a distracted thinking in general. And the individual needs to desobjectivate it, take possession of implemented there types of activity (Rozin, 2013). Remaining a "lifeless" subject, the technology "comes to life", being brought into use by the society in accordance with its purpose. As a result, based on its genesis and conditions of functioning, the technology as a social subsystem has two significantly different, but inseparably linked and attributable to each other "images" – ideal and material, and can be understood only in their "duality".

Technical thinking is no less important and essential constituent of technology than its material embodiment. It, in the same manner as thinking, is a specific feature of a person. As a physiological process it occurs in each individual brain, but in obligatory interaction with other individuals, the "connection" with which is carried out through the re-encoding of "internal" nerve impulses into "external" generally significant signals through the sign systems and vice versa, which makes individual mental cogitative processes a public one. Accordingly, the result of mental processes objectification is the creation of two different types of material formations – carriers of the pointed signals (signs) and technical objects.

Creation of technical objects at any level of technological development requires appropriate knowledge, which can be obtained in different ways: directly in the process of life-activity (practice); on the basis of aloof observation (contemplation); during the purposeful influence on the subject, its study (experiment). Considering the systemacity of the world around us, on the one hand, and the "fragmentation" of knowledge in different "heads" – on the other hand, they should always be conducted to a system the character of which is determined by the level of knowledge. There are three such systems in history: mythology, philosophy, and science. However, only in the latter one two interrelated forms of cognition are clearly defined: experimental – with direct research of the object and theoretical – with the study of its simplified model created for this purpose (Gryffen, 2012).

Nowadays, scientific knowledge has taken the dominant position and covers almost all reality. The system of sciences, the constitution of which is defined differently, was formed. In the most "objectivistic" system (according to "the forms of movement") sciences are divided into natural, with appropriate subdivisions, and social. There is no place for technical sciences in such system. However, often the division of sciences is made according to their purpose: the study of society itself and its habitat. Then the existence of technical sciences, the object of which is the technosphere, which divides (and connects) the natural environment and society as a specific phenomenon of the real world with its features, is natural.

Belonging to that kind of sciences system, the technical sciences still significantly differ from others relative to the specifics of its objective existence (its "manmade" nature) and their own purposes. A Nobel prize holder, a prominent American scientist Herbert Simon emphasized that if the main purpose of natural sciences is perception (analysis prevails), so for the technical sciences an ultimate purpose is to create a "second nature" (synthesis dominates) (Sajmon, 2004) In an experimental research, the main thing is not to obtain knowledge, but to improve the object. As for theoretical research, since in each case the ultimate goal is to create a class of technical devices, a kind of simplified model turns out to be a specific real device of this class.

The creation of technical devices is carried out by society to meet the needs of a person, and therefore their character and "nomenclature" are largely defined by these needs (Maslow, 1954). Among a significant number of systems emphasizing different human needs the so-called "Maslow's hierarchy of needs" is the most wide-spread.

However, it does not take into account the fact that the carrier of needs – the individual – is simultaneously an element of higher integrity (society). It is he who, by virtue of his complexity and his own prehistory, is an integral system. It follows that two interconnected systems of needs are peculiar for a person. Thus, the composition and functions of the technical system should take into account both individual needs of a person (in objects of assimilation, creating comfortable conditions, providing constant physical and mental job), and social needs (in society as such, communication, self-esteem).

In primitive society, a complex of things that provided material interaction of the tribe community with the environment, was concentrated in the dwelling of that time (including the latter) (Tolochko & Stanko, 1997). With respect to the unity of production and consumption, the labour sharing (except sex and age distinction) did not exist as well as the differentiation of technical objects types. At the same time, the dwelling became an environment which confronted the external world, it was the place of each individual person formation – both in desobjectivation of manmade objects and in meeting social needs. Therefore, in this case, the technical system was of a syncretic character.

The technical objects, usually called consumption items, first of all, serve to meet the individual needs of people. Regarding assimilation problems, the consumption items mainly play a supporting role. And the needs of comfortable conditions are almost fully provided with their help. The appointed needs have a wide assortment – from clothing to sports devices. In fact, these very items are the things a person really needs.

However, the "man-made" nature of the necessary consumption items naturally causes the appearance of other technical devices, which are not directly aimed at meeting human needs, but provide the possibility of their creation – the production tools (or, more broadly, means of production). One of the first to deal with the problems of aesthetics of technical objects and industrial design was Franz Reuleaux (1829–1905 biennium), an outstanding German mechanic engineer, lecturer of the Royal Technical School in Berlin (nowadays, Berlin Technical University). He was called "Poet of Technology" and believed that with the help of technical devices in general, or tools in particular, we make "the internal processes of the material world to act and work for our purpose" (Ryolo, 1885, p. 1). They provide the creation of other types of technologies, in particular the means of production, for further technological progress. The importance of this type of technology involves their significant influence on industrial relations, namely, the social system, creating working conditions. In the process of society and technology development, this type of technology progresses at the fastest pace and becomes the most diverse. It consists of numerous classes and subclasses, significantly expanding social opportunities in interaction with the environment (McLain, Irving-Bell, Wooff, & Morrison-Love, 2019). Thus, it should be logical to conclude that the means of work are not only the criterion of the human

labour power development but also the indicator of social relations in which labour is carried out.

However, the society in interaction with the environment faces the need to act in the form of integrity, which with its quantitative growth and spread also involves the use of certain technical means (in order to provide integrity). The means of communication supposed to provide material (substantial and energetic) (transport) and informational (linking) streams serve as unifying, integrated objects. They fulfill this role both in reference to the elements of society – individuals and social groups, and to their production activities. The latter comprises communication means as belonging to the means of production.

The increasing number of social entities leads to the intensification of various kinds of contacts between them. The growth and complicacy of each entity are also accompanied by structural changes. They are primarily connected with the distribution of labour and the distinguishing of separate production social groups with different interests. In both cases, the appropriate types of technical devices (separate) are needed, which, above all, include weapons and military technology in general. Another type of technical devices of this kind is articles of luxury. Such articles can be used both as special technical devices and the objects of other technology types, which obtain a high-status character.

Accordingly, the technology is a system with a complex structure, which is due to its transformation into a dynamic developing system. In this context, the technosphere is compared to the biosphere. It stands to reason that there is a significant difference between the elements of these dynamic systems – the biological personality and the technical device (product). First of all, it is the difference between the living and the lifeless. This specific element includes differences both in functioning (regarding entropy) and in structure (heterogeneity of materials in the first case, and homogeneity – in the second one). However, there is something in common between them, as complex formations require a certain "previous plan" for their implementation. Although there are significant differences in this case too (Libberta, 1982, p. 18).

The biological personality is self-created in accordance with the program laid in its genotype, which is connected with each cell of the organism. Its "construction" is a process that in ontogenesis repeats phylogenetic development – since a biological person, regardless of the development level in ontogenesis, should successfully function in the environment as a separate organism at each stage. The technical device is created by a society from ready-made components, and only in a programmed form it starts to function by itself. But it also needs some kind of genotype – external in regard to this device. Today, such a "genotype" is a document (sometimes called a passport), without changes in which no "phenotypic" transformations in the device is possible. Still, in both cases, the new peculiarities of "organisms" arise in the form of random mutations in the genotype, which are fixed in with respect to natural selection or social practice.

Another important similarity of technical and biological is that in both cases a separate “organism” can only function in a particular conglomerate (Malaspina, 2019). This refers not only to the biosphere or the technosphere as a whole but also to some local unities, which are called "biocenosis" in relation to living organisms. Technical devices, by analogy, received such name as “technocenosis”. Cenosis is a kind of system that differs from the system properly in that its whole structure is influenced much more by the properties of separate components which are already included in it. These communities of any kind have a common – *as distinct from Gaussian* – nature of the elements distribution. It is in the composition of cenosis that specific technical devices perform functions in the technosphere, and therefore largely determine the dynamics of the latter.

It stands to reason that the development of technology in general and in its structural and functioning units, as well as any material objects, is directed by certain patterns. Therefore, the researchers seek to find the “general laws” of this development. In our opinion, such question setting is as scientifically incorrect as attempts to find the “general laws” of physics or biology. Regarding the technology, the attempt to use the so-called “laws” of Hegelian dialectic cannot be recognized as legitimate. These “laws” are designed for an ideal single object that does not arise, does not disappear, and does not come into interaction with anything. This fundamentally distinguishes an ideal single object from real objects. Valid “laws of technology” should concern its real objects, even if they have different levels of generalization and idealization.

Since the development of technology is a historical process, there is a problem of its periodization. The corresponding numerous periodizations are reduced to two basic principles. As for *the first*, the periodization of the development of technology as a social phenomenon should coincide with the periodization of society development; according to *the second*, the technology in its development is self-sufficient, subordinate to its own laws and not only independent of the development of society but dramatically affects it. Both principles reflect the significant features of technology and have the right to exist. However, in reality, the development of technology that complies with two different types of consistent patterns, cannot be determined by any of them. Therefore, the periodization of its development can be the only relative, depending on the purpose of the research.

The main direction of the general development of technology is the gradual transference of partial technical functions of a person to technical devices. Initially, it concerned the tool that interacted with the subject of work and changed it directly; subsequently – types of energy spent by a human being on this interaction (muscle strength, then – the energy of animals, and then – the forces of nature), and finally control and management of these processes. Today, despite the importance of all appointed aspects, the latter gained special attention. It is associated with a significant increase of productivity, and what is the most important, a gradual more and more complete transference of “alive” workers’ functions to the technical systems.

Eventually, the time when only the purposefulness and general control will be kept by a person and everything else will be performed by technical systems will come.

Conclusions.

One of the most important social phenomena – technology, comprises a created by mankind in relation to the environment a special sphere that separates them and simultaneously connects with each other. Materially specified technosphere consists of a system of technical devices designed both to meet the needs of separate individuals and society as a whole. However, the set of technical devices inherently is not yet a technology, because only the direct efforts of people "restores it to life" and makes it effective. The development of technology is of spontaneous character and is determined by the momentum of socio-historical evolution, not intrinsically but through interaction with the relevant structural and functional changes of human society.

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The author declare no conflict of interest.

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Техніка, як соціально-історичне явище

Анотація. *У статті презентовані уявлення авторів про сутність техніки, як соціально-історичного явища. В його основі лежить погляд на техніку не просто як на сукупність технічних пристроїв, але як на підсистему загальної системи – суспільства, що розташована між соціумом і його природним оточенням у вигляді своєрідної суспільної техносфери, що їх одночасно розмежовує й об'єднує. Основне об'єктивне призначення техносфери – сприяти ефективному винесенню генерованої суспільством ентропії назовні; воно визначає характеристики техносфери як соціально-історичного явища. Аналоги такого роду матеріальних утворень мають місце й у тваринному світі (від павутиння до бобрової греблі), однак є поодинокими й виникають унаслідок реалізації інстинктивних програм особин. У свідомості людини такі програми не закладаються "природою", вони формуються на основі "розпредмечення" наявних у суспільстві технічних об'єктів. У процесі "розпредмечення" сутність, "логіка предмета" стають досягненням людини і завдяки її здібностям наповнюються новим змістом. У такий спосіб, техніка становить явище матеріально-ідеальне: з одного боку це сукупність технічних об'єктів, а з іншого – технічне мислення людини, вищим проявом якого сьогодні є технічні науки. Власне, технічні об'єкти створюються суспільством для задоволення індивідуальних і суспільних потреб людини. Це, перш за все, предмети споживання; у зв'язку з їх рукотворністю постає питання розвитку засобів*

виробництва, що з часом набуває все більшого значення, особливо завдяки їхньому істотному впливу на всі суспільні структури (які згодом для реалізації конкретних завдань також вимагають певних технічних пристроїв). Комплекс цих пристроїв формує техносферу суспільства як складну цілісність. Складниками техносфери стають не лише групи різних за призначенням технічних об'єктів, але й їхні конгломерати, призначені для виконання певних функцій, які, аналогічно до біологічної галузі, отримали назву техноценозів; в останніх за рахунок своєрідної "конкуренції" відбувається розвиток указаних складників зокрема і техносфери в цілому. Однак, попри системність, техносфера є підсистемою суспільства, отже, годі сподіватись на віднайдення окремих законів її розвитку і створення відповідної цілісної періодизації. Тому наукова періодизація розвитку власне техніки пов'язана з метою конкретного дослідження і визначена нею.

Ключові слова: *техніка; техносфера; технічне мислення; технічні пристрої; техноценози*

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Техника, как социально-историческое явление

Аннотация. *В статье изложены представления авторов о сущности техники, как социально-исторического явления. В его основе лежит взгляд на технику не как на совокупность технических устройств, а как на подсистему общей системы − общества. Расположенная в виде своеобразной общественной техносферы, между социумом и его природным окружением, она одновременно разграничивает и объединяет их. Основное объективное назначение техносферы − способствовать эффективному вынесению генерируемой обществом энтропии наружу; оно определяет характеристики техносферы как социально-исторического явления. Аналоги такого рода материальных образований имеют место и в животном мире (от паутины до бобровой плотины), однако они единичные и возникают вследствие реализации инстинктивных программ особей. В сознании человека такие программы не закладываются "природой", они формируются на основе "распредмечивания" имеющихся в обществе технических объектов. В процессе "распредмечивания" сущность, "логика предмета" становятся достижением человека и, благодаря его способностям, наполняются новым содержанием. Таким образом, техника представляет явление материально-идеальное: с одной стороны, это совокупность технических объектов, а с другой − техническое мышление*

человека, высшим проявлением которого сегодня являются технические науки. Собственно, технические объекты создаются обществом для удовлетворения индивидуальных и общественных потребностей человека. Это, прежде всего, предметы потребления; в связи с их рукотворностью возникает вопрос совершенствования орудий производства, что со временем приобретает все большее значение, особенно благодаря их существенному воздействию на все структуры общества (которые для реализации конкретных задач также требуют определённых технических устройств). Комплекс этих устройств формирует техносферу общества как сложную целостность. Составляющими техносферы становятся не только группы различных по назначению технических объектов, но и их конгломераты, предназначенные для выполнения определенных функций. По аналогии с биологической отраслью они получили название техноценозов, в последних за счет своеобразной "конкуренции" происходит развитие указанных составляющих в частности и техносферы в целом. Однако, несмотря на системность, техносфера является подсистемой общества, следовательно, не стоит надеяться на обнаружение отдельных законов ее развития и создание соответствующей целостной периодизации. Поэтому научная периодизация развития собственно техники связана с целью конкретного исследования и определена ею.

***Ключевые слова**: техника; техносфера; техническое мышление; технические устройства; техноценоз*

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Management and communication ideas in the late 17th – early 19th centuries

Abstract *The article examines the period from the end of the 17th century to the beginning of the 19th century, when on the basis of deep philosophical concepts, a new vision of the development of statehood and human values raised. At this time, a certain re-thinking of the management and communication ideas of Antiquity and the Renaissance took place, which outlined the main promising trends in the statehood evolution, which to one degree or another were embodied in practice in the 19th and 20th centuries. A systematic approach and a comparative analysis of the causes and consequences of those years achievements for the present and the immediate future of the 21st century served as the methodological basis for a comprehensive review of the studies of that period. The scientific novelty of this study is the demonstration of the theoretical heritage complexity of the Enlightenment for the general history of management and communication ideas. The article presents an analysis of the views and concepts of the late 17th – early 18th century thinkers Thomas Hobbes and John Locke, who defend the right to freedom of communication and liberalization of relationships in the system: "person – society – state", associated with their own understanding of the government role. French enlighteners François Voltaire, Denis Diderot, Jean d'Alembert, Etienne Condillac were much smaller theorists in management and communication issues, but their successful epistolary and encyclopedic communication practice, starting from the third decade of the XVIII century significantly increased the self-awareness of the masses. The influence of their ideas on the possibility of progressive development of social relations, on improving the national states manageability and on how of a new type scientists were able not only to popularize knowledge, but also to practically make it an object of public communication is shown. In this context, the author considers the importance of political and legal communication problems in the vision of Charles Louis Montesquieu and analyzes the republican governance ideas by Jean-Jacques Rousseau as an outstanding figure of the Enlightenment, who attached great importance to the forms and methods of forming of the state governance structures. At the end of the historical period under consideration, a comparative historical analysis of the most significant statements of such thinkers as Immanuel Kant and Georg Wilhelm Friedrich*

Hegel is presented. These founders of the scientific discourse around the problems of power and state, war and peace, the effectiveness of government and communication in relations with the people laid the enduring foundations of the theoretical argumentation of two opposing views on the cardinal problem of our time – the possibility or impossibility of achieving mutually acceptable foundations of a new world order peacefully, excluding all types of hybrid wars. The general picture of the scientific and technological achievements of this period, influencing the level of understanding of the management and communication functions of the state of that time, is given in comparison with the present.

Keywords: *power; state; state administration; communications; comparative historical analysis*

Introduction.

A public discourse on the state administration principles and methods requiring a respect for the freedom of speech in a situation of continuing hostilities, aggressions, information wars, ideological and other confrontations between states and civilizations is becoming more and more crucial and critical. This requires the conceptual comprehension of the causes and consequences of these phenomena and a proper comparison with the sources of the ideas and theories relevant to these human life fields. From a historical perspective, a period from the late 17th century to the early 19th century was the time of the critical rethinking of the scientific heritage of the past epochs and the relevant worldviews. In the historical interval from the English Glorious Revolution to the consequences of the Napoleonic wars, the Enlightenment[1] was the central and essential epoch characterized by a fundamental breakthrough in the theory and practice of scientific and public communications. A critical analysis of the civilization project covering the latest five centuries, including the subject period, is provided in the book by Max Horkheimer and Theodor W. Adorno titled "Dialectic of the Enlightenment. Philosophical Fragments", where a specific communicative strategy was used for the author's message of his evaluation of the positive and negative sides in the past to the future generations (Horkheimer, Adorno, 2002, pp. 2, 95, 96). The work by Marshall McLuhan titled "The Gutenberg Galaxy. The Making of Typographic Man" provides an analysis of a universal tool of the humankind communicative experience, which led to negative consequences such as individualism, nationalism, and militarism. McLuhan hoped that the new information and communications technology would bring about significant changes in all the areas of mankind and would gradually eliminate these defects (McLuhan, 2015, pp. 28, 29). Changes did happen, but the aforesaid negative sides did not disappear. The practices and theories in the mid-20th century and the first two decades of the 21st century proved

[1] The Enlightenment is a key epoch in the history of European culture associated with the development of the scientific, philosophical, and social thinking. It was based on an intellectual movement with rationalism and free thinking ideas. Its division into periods is polemical, for example: 1715–1789 or the entire 18th century, or a period from the late 17th century to the early 19th century.

in principle Thomas Hobbes' postulate, expressed back in the 17th century, concerning the primacy of the speech reflection of the thinking process through any innovative technical means (Hobbes**,** pp. 16, 17).

The contemporary concepts of communication studies in the administration systems were developed by prominent scientists and thinkers such as Jean Baudrillard, Norbert Wiener, Niklas Luhmann, Claude Shannon, Roman Jakobson, and many other specialists. Several national researchers greatly contributed to the study of this issue, but a small number of works were dedicated directly to the history of the state communication studies before the early 20th century.

The issue of searching for the efficient mechanisms and means of modernization of the administrative structures of government bodies and their communication support makes one look, in particular, at the experience of the theoretical and practical developments of various epochs historically preceding the fundamental transformations of society. This is the main objective of this publication.

The publication's key goal is to analyze the opinions and ideas of the thinkers of the late 17th century – the first decades of the 19th century associated with the comprehension of the role of communications and administration, their ideas' impact on the opportunity of the progressive development of national states and humankind in general.

Material and methods.

The methodological procedures for studying the ideas of the thinkers of the late 17th century – the early 19th century in the area of administration and communication processes were based on a system approach and a comparative historical analysis of political treaties written before the French Revolution as well as philosophical works produced in the course of the industrial revolution. A comparative historical analysis helps determine the place, role, and meaning of the scientific works of the subject period in the evolution of the theoretical ideas about the nature and essence of administration and communication in the civilization development of humankind. A system analysis of research works in that period must contribute to the fresh historical and philosophical rethinking of the importance of works written in that epoch for using certain theoretical messages in the new concepts of the third decade of the 21st century. The study is based on the translations of sources in an electronic and hardcopy form and relevant literature, as well as general historical works dedicated to this historical period.

Theory.

A contemporary intensive scientific discourse on the freedom of information and communications with a need to preserve controllability in a situation of permanent crises and various interstate confrontations urges to search for new solutions, including with the help of the theoretical historical similarities and adequate ideas in the critical judgments of the past thinkers. Their interpretations in a purposeful system statement

adapted to the contemporary comprehension of terms may prove to be quite interesting for forming new scientific provisions. A characteristic epoch of the critical rethinking of the antique heritage and worldview trends was a period called in the history of Europe the Enlightenment. The Enlightenment inherited from the Renaissance[2] two contrasting views on the goals and purpose of state administration and the role of communication in this process. In the 17th century, John Locke, a precursor and father of this epoch, argued that the successful development of a national state and reasonable management of society was possible in an enlightened constitutional monarchy governed by a humanitarian paradigm of its mission based on the liberal ideology. The opposite (Machiavellian) concept justified and encouraged any means, in particular, the most cynical, manipulative and deceptive ones, supporting, in an uncompromising, tough, and consistent way, the authoritarian rules, a strict hierarchical order and the negative characteristics of the human nature in cynical rulers.

Although in the 17th century Thomas Hobbes and John Locke provided comprehensive arguments to advocate the freedom of communications, liberalization of relationships and relations within the human being – society – state system, the successors to their ideas, i.e. the representatives of the Enlightenment, relied on the triumph of the mind of the rulers and the elite. The French Enlightenment ideological movement was theoretically much less immersed in the specific government and communication issues. Their successful practical experience in the epistolary and encyclopedic communications is of utmost methodical and applied importance in the history of science. But the key achievement of their works is the impact on the philosophy of Kant and Hegel.

The scientific innovation of this historical study consists in the evaluation of the importance of the theoretical ideas stated by the thinkers before the early 19th century to freshly rethink their relevance to and harmony with the statements of the specific structures of the concept of the future general planetary (noospheric) government within the context of the communicative component of the new world order in the 21st century.

Results and Discussion.

1. Ideas of the precursors of the Enlightenment

Treaties written by the prominent thinkers of the Antiquity[3] and the Renaissance served as a fundamental basis for the successful and fruitful activities of the enthusiasts in the Enlightenment period. In the 14th century, Francesco Petrarca freed Plato's and Aristotle's antique heritage from scholastic and dogmatic blinkers of the Middle Ages,

[2] The Renaissance is an epoch of the worldwide importance in the history of European culture that followed the Middle Ages and preceded the Enlightenment and the Modern Age. Periods and dates are conditional and polemical. In Italy, it developed in the early 14th century. The Renaissance decline is viewed differently as well: from the last quarter of the 16th century to the 18th century (in Russia). In various countries across Europe: until the first decades of the 17th century.

[3] The Antiquity is an antique epoch of the Greek and Roman civilization of the worldwide importance with a diversity of its forms, which had an influence on the historical and cultural development of humankind. Division into periods is polemical. For example, the 8th century BC – the 5th century AD or around the 7th century BC – the 4th century AD.

and historian Leonardo Bruni pointed in the 15th century to the methods of the republican rule and the issue of the freedom of communication. In the 16th century, Jean Bodin managed to expand and deepen the comprehension of government providing a basis for the state administration concept until the 19th century. Niccolo Machiavelli and Hugo Grotius looked at communication between the state and the population, the war and the peace principally from different positions and imposed this discourse in the 15th – 17th centuries to be continued until now.

Immediately after the Glorious Revolution in England, in 1690, John Locke (1632–1704) published his work "Two Treatises of Government" and several other works. He stated his philosophical views on the state administration principles; introduced for the first time the concept of separation of power; marked the limits of the ruler's (constitutional monarch's) powers, full powers of the legislative and executive authorities, a people's possibility to revolt and topple the government. Locke also provided a comprehensive and liberal scheme of prospective communication between the government and the enlightened elite. In this way, he turned out to be a transitive figure between the two bright and unique epochs: the Renaissance and the Enlightenment, being considered the father of the latter. Opinions about their boundaries vary, but it is clear that the Glorious Revolution and its consequences influenced Locke's works and became a starting point in the historical measurement of these epochs.

According to the liberal constitutional and liberal democratic views proposed by Locke, politics and political communication should be based on the individual – society – state model. Man and his interests, values, and demands moved to the foreground. And the state occupied just the third (last) position. He believed that the constitutional monarchy was a perfect form of statehood. In his work "Two Treatises of Government", Locke focuses his reader again and again on his main postulate: man is naturally free. In Locke's view, the state represents the voluntary limitation of man's freedom for the sake of his own and society's welfare. It must always develop legislative and executive authorities by taking into account this factor **(**Locke, p. 106, 114, 146, 147). Pathos of these ideas is underlying the works written by Locke, a father and oracle of social and political concepts of the 18th century thinkers, who decided to implement and develop the main provisions of this doctrine through their practices.

2. Practical communication of the Enlightenment representatives.

2.1. Communication practices of enlightened encyclopedists.

Starting from the third decade of the 18th century, an entire galaxy of prominent thinkers managed to implement their ideas through their publishing and educational activities designed for the most influential monarchs of that period and the progressive elite of European society. Most of the inspirers and bright figures of the French Enlightenment such as François Marie Arouet Voltaire, Denis Diderot, Jean Le Rond d'Alembert, Etienne Bonnot de Condillac were consistent followers and practitioners of an enlightened monarchy. They engaged in active epistolary communication

practices with Europe's influential monarchs, including Catherine II and Frederick the Great. Their successful communication and popularization experience played a prominent role in the political history of many states. This makes us look at their heritage when rethinking the contemporary theories of general government and communication studies. Such studies are also necessary to find the starting points of the prospective scientific areas in the information field. The philosophical and socially important ideas of this epoch, which had an impact on the European and American culture development, play a leading role for contemporary studies as well. Free thinking and rationalism in evaluating the vital phenomena developed in the Enlightenment period are necessary, in particular, in their direct implementation for an intensive social discourse in Ukraine as well, which is suffering from a deep hybrid crisis. Some countries of Central America and Middle East are experiencing a similar critical situation as well. A vital crisis of administrative and communication structures is one of the key components of these encompassing hybrid crises (Kislov, 2019, p. 76).

As scientists of a new type, the representatives of the Enlightenment not just popularized Knowledge, but tried and managed to make it the subject matter of public communication. The peak of these aspirations was the work "Encyclopedia, or a Systematic Dictionary of the Sciences, Arts, and Crafts" published in France in 35 volumes in 1751–1780 on the initiative of Diderot and d'Alembert. In Germany, the 68-volume "Great Universal Lexicon" by Johann Heinrich Zedler was published in 1731–1754. This was the largest encyclopedic publication of the 18th century, which can be used even now for some references. In Europe and North America, other encyclopedic publications and dictionaries appeared as well, which varied in terms of importance but were less famous. But the authors of articles in the French Encyclopedia were famous scientists with progressive ideas, carefully and comprehensively preparing materials for each article, using creative approaches and discussion topics. For this reason, the communication discourse of the Encyclopedia played both an educational and revolutionary transformational role in the history of Europe and partly the entire humankind. However, the principal importance of the French representatives of the Enlightenment consisted in their influence on the philosophy of Kant and Hegel. Republican Jean-Jacques Rousseau was one of these thinkers although his doctrine was polemical (Dlugach, 2001, pp. 249, 250).

2.2. Jean-Jacques Rousseau's republican rule ideas.

Being a prominent representative of the Enlightenment, Jean-Jacques Rousseau (1712–1778) paid great attention to the forms and methods of formation of the governing structures of the state. Yet he left no important ideas about the administration to communication relation and their interaction. However, all of his political journalistic activities aimed at forming public ideals in the mid-18th century serve an example for applying a new, dynamic, contradicting, and even paradoxical form of political communication. Advocating and opposing the existing forms of state administration at the same time, Rousseau, following dualistic ideas, on the one hand,

was a supporter of the Social Contract in an idealized small republic between its citizens (or subjects of Law). But, on the other hand, he argued that there is no and can never be a democracy in its pure form since a conflict between a right to freedom, full government by the people, and the private interests of any ruling elite cannot be settled in principle (Rousseau, pp. 19–21). For this reason, Rousseau actively opposed any party systems, particularly a one-party rule. He argued that power in a republican state may in no way be held by one association (a party, a single majority, or any similar organizations) as, in this case, the private interests of this situational single association will unavoidably be antagonistic to the interests of the entire people as the only sovereign of power and all the other political forces in society representing various group interests. Rousseau wrote that the private will (of an individual, a party leader, or a single majority) will always seek to get advantageous (Rousseau, 1998, p. 216). This has been the case in contemporary Ukraine. Having democratically given power to one political force with unclear ideals and a formless worldview doctrine, the population, as a result, received a puppet government of the representatives of the single majority in the legislative and executive branches. Having no stable views on the strategic objectives and methods of governing the state system of their own country, those in power started to follow an external corporate ideological doctrine, which is alien to the people. This is the current social and economic situation in Ukraine exacerbated by a military conflict in the East of the country and the costs of a protracted information war (Kislov, 2013, p. 198, 201). In this connection, one is tempted to refer to historical analogies as Rousseau, a thinker of the Enlightenment period, pointed to the unavoidable decline of this system. This can happen in a situation where the war and peace issues are not dealt with based on the "common will", but in the private interests of only one group, i.e. an association, a party (Rousseau, 1998, p. 218).

3. Political and legal communication issues as viewed by Charles Louis Montesquieu.

Considerable contribution to the development of the political thought, in particular, the political and legal issues of communication was made by French philosopher and political scientist Charles Louis Montesquieu (1689–1755). As one of the founders of the theory of a law-governed state, he argued that the branches of powers not just had to be separated, but there must be a guarantee that these branches could be headed by the representatives of different political forces with independent communications systems. And each of the branches of power should have no right to cancel the decisions of the other branches of power, but could just suspend them in case of emergency (a threat to the security of the state, contradictions to the law of the country). In this way, there would be a system where each branch of power could control the other two branches of power. According to Montesquieu, in this case all the branches of power could be mutually controlled. Being interested in preserving a monarchy with the growing financial power of the bourgeoisie, Montesquieu managed to brightly balance, in legal terms, the principal interests of only two classes:

aristocracy (nobility) and bourgeoisie, by using the delicate mechanisms of rights, freedoms, and benefits. He believed that this balance was the basis of the stability of the regime in his system of state power. But this would be a very delicate, thin, i.e. fragile system of power. Montesquieu was aware of it so he insisted that the system of balanced benefits and rights should never be cancelled as, otherwise, the levers of power would go to the other classes of the population and this system would collapse. In this case, there would be a threat that it would later lead to despotism or dictatorship of the masses (crowd) and similar phenomena.

Among the principal laws regulating social life, Montesquieu considered one of them (third in the hierarchy): communication between people and aspirations to improve and expand it. For him, the first and dominating law was actually specific communication with God. The need to provide food was the second law. Therefore, the need for food and communication was considered by him in the same logical category (Montesquieu, 1777, pp. 32, 33).

Being a representative of the geographical scientific school, Montesquieu argued that political communications, their intensity, legal legitimacy, and the form of legal regulations depend on the geographical location of the state. He also emphasized that, apart from the principal and determining geographical reasons having an impact on the communicative field of the state, other aspects have a significant influence as well: environment, economic component, mentality, religion, demography, and so on. He argued that the Spirit of Law must be closely related to all the other aspects of communications in society in terms of the purpose of its successful and balance development.

Therefore, Montesquieu proposed a clear idea that an effective and adequate legal mechanism of the state will be efficient for the evolution only when it is carefully corrected with respect to the nature and other components of the nation's life under the objective conditions of the natural and resource factors of the environment. This fundamental principle is ignored by the doctrinal systems of various unions and blocs with respect to the dependent or member countries and nations, which at present unavoidably leads to the need for deploying intensive information and psychological operations aimed at suppressing or breaking the mentality, traditions, and forms of existence of many peoples under the modernization and civilization slogans. The demand for freedom of political communication was one of the most important aspects of Montesquieu's theory (Antolohiia liberalizmu: polityko-pravnychi vchennia ta verkhovenstvo prava, 2008, p. 420, 441–443). For this reason, Montesquieu argued that the law-governed state theory has both historical and practical importance for establishing the balanced regulations of information and communication law to ensure comfortable conditions of existence of the contemporary sovereign countries. This regulation is a basis for the national information and psychological security of peoples when a condition of "independent dependence" is imposed on them.

4. Political ideas of great German thinkers.

A further impact on the development of future information and communication theories was made by the political ideas of great thinkers such as Immanuel Kant (1724–1804) and Georg Wilhelm Friedrich Hegel (1770–1831). Their fundamental theoretical concepts, which had and continue to have a strong influence on the development of political ideas and ideologies in the 19^{th} – 21^{st} centuries, formed a basis for the practical implementation of liberalism and communism (Marxism), socialism and nationalism for two hundred years ahead. The works of these authors include the conceptual aspects relevant to the communicative components both within the state policies and at the international level.

4.1. Kant's idea of the administrative and communicative future of humankind.

Kant's idea of what we presently call communication is specific to some extent, but it corresponds to his vision of a human, people, and state in the concrete and ideal terms and is also limited to the same conventions that are typical, in principle, of antique authors. Man occupies a priority place in Kant's political doctrine. However, he considers man in two forms at the same time: firstly, as an empirical being (i.e., a being that cannot be free due to the law of causation shown in his behavior); secondly, as a being – thing in itself (i.e., a fully free being according to the moral laws and supposed to act according to the main principle or rule of the "categorical imperative"). This meant, in Kant's opinion, the final behavior of a human being where his real actions can correspond to the maximum extent to the principles of the all-encompassing legislation. And true communications arise and have a right to exist only in this case.

According to Kant, man is an "absolute goal" as an abstract being. Therefore, a specific human can logically be only a means of achieving this goal. And all the general and individual communications of humankind must correspond to this postulate so as to contribute to the permanent and untenable aspirations from the specific condition of relativity to getting closer to the absolute condition of the thing in itself by following the categorical imperative principle. Therefore, the information and communication components of society are fully subordinated to two control functions: morality and law with morality unconditionally prevailing (Kant, 1980, p. 189).

According to Kant, humankind is to achieve the level of a true civil society that will follow the principle of each individual's self-evaluation. And then the objective of the state is to fully implement the ideas of law. Kant stated that in a law-governed state power belongs to the sovereign people (but these are only active citizens; not women, servants, marines, apprentices, hired workers, or other lower classes of society). Therefore, legal communication, according to Kant, in a law-governed state can exist only in the morality area. Legal moral information can circulate within the framework of legal communication. Therefore, any other information will be automatically recognized as immoral. And then, in this thinker's opinion, any information and communication confrontations in the future would be ruled out. In other words, Kant

believed that the "perpetual peace" would rule out a possibility of information wars (Kant, 1980, pp. 195, 196). But, on the contrary, humankind did not follow the path proposed by Kant and made information confrontations a permanent and continuous phenomenon.

In international politics, Kant's ideal consisted in the total neutrality and formation of a global civil society as part of a global federation of independent and free states. He stated all of his "perpetual peace" ideas in his work bearing the same title. These ideas and opinions proposed by Kant have their followers and supporters at present as well, despite the entire theoretical ideality of their structure. Contemporary Neo-Kantians believe that the globalization process can be fairly completed only in the way viewed by Kant. In this context, obviously there were hopes to form a society of knowledge according to the Kantian idealized model as well. However, political reality of our days is in full conflict with the logic of Kant's theories immersing the political struggle into the abysm of the global information war.

4.2. Administration and communication ideas of the system proposed by Georg Wilhelm Friedrich Hegel.

In his huge philosophical heritage, Hegel rejected both Kant's social development concepts and Rousseau's natural law ideas of the social contract. He fully rejected Kant's idea of the "perpetual peace" in its global definition. Hegel believed that only a war can help overcome a confrontation between the "conflicts of sovereignties" of various states and avoid the "stagnation and decline" of strong nations. For him, wars represented one of the aspects of a permanent and continuous struggle in all the fields of international relations. But just as Kant, he ruled out certain peoples from the participation in any state or creation activities. Hegel extended this approach to all the Slavonic nations in particular.

Unlike Kant, Hegel stated that not the imperative of peace, but, on the contrary, the imminence of wars of all types and forms was the destiny of humankind for a long time. Anyway, he proved to be right over 200 years after him. Therefore, as prolonged to our times, information wars are an imminent consequence of the rivalry between states in their fight for achieving an "absolute spirit". Hegel based his vision of state development on the "spirit" concept that may have three forms: a subjective spirit, an objective spirit, and an absolute spirit. The first two forms of the spirit are studied through the absolute spirit. A state emergence is a consequence of the "popular spirit" as an objective spirit. And a state is a way of domination over the subjective (personal) and objective aspects (Hegel, 1978, pp. 75–77).Therefore, ideally this is the absolute spirit implementation. Only the subjective and objective communications leading to the formation of the absolute spirit communication are worth being studied and analyzed while the others should be dismissed by researchers, and so should be nations failing to form their state (Hegel, 1978, pp. 81–84).

Because of his radical ideas and predictions that came true, Hegel is considered a precursor of totalitarian regimes and world wars in the 20th century as well as local

wars for the global interests continuing in the 21st century. This is why Hegelianism is criticized. But the ideas and some statements of his doctrine had a huge influence on many thinkers of that epoch, in particular on Neo-Hegelians such as Karl Marx and Friedrich Engels and their followers.

Hegel was one of the critics of the arising industrial society. He established a link between the growing mechanization, labor division, and social exclusion, making communication difficult and deforming it. Hegel was among the first philosophers to realize the importance and need to scientifically rethink the economic development problems and consequences.

In 1820, Hegel published his "Philosophy of Law"[4], which, in principle, completes his all-encompassing system of the development philosophy. In order to create his system, he often used artificial (coercive) structures, which are still subject to a discourse and criticism of his opponents. These structures serve as a basis for building a principal, logically harmonious and holistic structure of the future. It is necessary to penetrate deeper into the sophisticated labyrinths of the structure of his system to detect quite a useful treasury of ideas, which are valuable even today when a new philosophy of administrative and communication process is being developed.

4.3. Scientific and technical achievements and level of understanding of administrative and communication functions.

In the late 18th century, fundamental changes in the means of communication – methods of communication (river, sea, ground transports) take place, particularly in England (Allen, 2014, p. 12, 13). Understanding and knowledge of communication processes gradually became necessary to organize collective labor. This stimulated the scientific thought to explain processes developed in social life and in government in other European countries. Good preconditions were created for analyzing and theoretically explaining communication processes; but the notion "communication" was conceptually formed only in the 20th century, including in its applied industry-specific areas.

The entire described historical period from the late 17th century to the early 19th century was characterized by inventions of new and improvement of already known steam machines, development of more improved steam internal combustion engines, and creation of practical samples of motor vehicles on their basis.

Creation of production and transport technical equipment developed the mass machine industry as a basis for the first industrial revolution of the late 18th century – the middle of the 19th century, which suddenly increased the labor output and communication opportunities of humankind (Bernal, 1956, p. 225; Mokyr, 2008, pp. 76, 94) This required a new state government system that would be immanent in the production forces, territorial, military, and communication purposes and ambitions

[4] Philosophy of Law by Hegel was published in 1820 although the original title of the book states 1821 as its year of publication.

of government. Napoleon I Bonaparte managed to practically create a system of state administration by using certain ideas and theoretical developments of the thinkers of the past in combination with his own vision of the functions of the tough centralization of the imperial state system. The state system relied on bureaucratically organized functionaries. Some elements of this structure were inherited from the old regime, from the period of the French Revolution, and rethought from theoretical models, but they were mainly the product of Napoleon's administrative creativity. Under Napoleon, the main administrative bodies were ministries created according to the principle of undivided authority and a tough executive vertical. By the end of Napoleon I rule, France had twelve ministries and one of the principal ministries was the ministry of trade and industrial policy (Tarle, 2010, pp. 79–81, 223–225; Tomsinov, 2011, pp. 119–122). After the Napoleonic wars and the Vienna Congress that determined the further destiny of Europe, there were publications pointing to the imminence of the industrial future of the countries of the Old Continent and America. These events ended the period considered in this publication.

Conclusions.

The key ideas of the thinkers and philosophers of the Enlightenment preceding the industrialization era and dedicated to the nature of administrative and communication processes generally repeated the theoretical statements from Aristotle to Locke. Indeed, the ideas proposed by Kant and Hegel, who philosophically rethought the heritage of the representatives of the Enlightenment such as Montesquieu and Rousseau, represented fundamental scientific worldview breakthroughs, leading to the deep rebuilding of many paradigms in the history, objectives, means, and development prospects of humankind. They had a considerable influence on the ideology and government practices of various countries and nations on the planet. The practice of the following centuries proved and enhanced the general meaning of the struggle of the two opposing concepts of the global development and fundamental approaches to the peace and war issues in global terms. For the contemporary world, the practical requirements of settling military and political, trade and economic conflicts and confrontations became an imperative of the humankind's future survival on Earth. The impact of the communication component on the development and interaction of administrative efforts made by some states and their associations has risen significantly over the last decades. This requires intensifying the events and concentrations of international contractual activities aimed at developing a new all-encompassing world order, taking into account the reality of the achieved potentials of the information and communication, military and economic influence of the confronted geopolitical forces. For these purposes, it is recommended to look at the sources of the comprehension of these processes to efficiently rethink them in contemporary conditions.

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Денис Кіслов
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Управлінсько-комунікаційні переконання кінця XVII – початку XIX століть

Анотація. *У статті розглядається період від кінця XVII сторіччя до початку XIX сторіччя, коли на основі глибоких філософських концепцій виникло нове бачення процесів розвитку державності та людських цінностей, а також склалося відповідне переосмислення управлінських і комунікаційних ідей мислителів Античності й Відродження, що визначили основні перспективні тенденції в еволюції державності, які в тій чи іншій мірі позначились у практиці XIX–XX століть. Методологічною основою з комплексного розгляду дослідження того часу став системний підхід і порівняльний аналіз причин і наслідків досягнень того часу на сучасність і на найближче майбутнє XXI сторіччя. Науковою новизною даного дослідження є показ комплексності наукового доробку періоду Просвітництва для загальній історії управлінсько-комунікаційних ідей. Представлено аналіз поглядів Томаса Гоббса та Джона Локка, які відстоювали право на свободу комунікації та лібералізацію взаємовідносин у системі “людина – суспільство – держава”, що було пов’язано з їх особливим розумінням проблем державного управління. Французькі просвітителі Франсуа Вольтер, Дені Дідро, Жан Д’Аламбер, Етьєн Кондільяк*

були менш значними теоретиками в управлінсько-комунікаційних питаннях, але їх успішна епістолярна й енциклопедична комунікаційна практика значно підвищила самосвідомість мас. Показано вплив їхніх ідей на можливість прогресивного розвитку соціальних взаємовідносин та на розвиток національних держав. З'ясовано як вчені нового типу спромоглися не тільки поширювати та популяризувати знання, але й практично зробити його предметом суспільної комунікації. У цьому контексті розглянуто значення політико-правових проблем комунікації в баченні Шарля Луї Монтеск'є та проаналізовано ідеї щодо прогресивного розвитку соціальної взаємодії на основі республіканського типу управління, які були висунуті Жан-Жаком Руссо – видатним діячем Просвітництва, що приділяв значну увагу формам і методам розбудови управлінських структур держави. На завершення періоду, що розглядається, представлено порівняльний аналіз найбільш значущих поглядів таких мислителів, як Іммануїл Кант і Георг Вільгельм Фрідріх Гегель. Ці фундатори сучасного наукового дискурсу навколо проблем держави й влади, війни та миру, ефективності державного управління та комунікації у взаємовідносинах з народом заклали основи теоретичної аргументації двох протилежних точок зору на кардинальну проблему сучасності – можливість чи неможливість досягнення взаємної згоди щодо встановлення нового світового порядку мирним шляхом, що виключає всі види воєн. Дана загальна картина науково-технічних досягнень цього періоду, які впливають на рівень розуміння управлінсько-комунікаційних функцій тогочасної держави у порівнянні з сучасністю.

***Ключові слова**: влада; держава; державне управління; комунікація; порівняльний історичний аналіз*

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Управленческо-коммуникационные идеи конца XVII – начала XIX веков

Аннотация. *В статье рассматривается период от конца XVII века до начала XIX века, когда на основе глубоких философских концепций возникло новое видение процессов развития государственности и человеческих ценностей. В это время произошло определенное переосмысление управленческих и коммуникационных идей Античности и Возрождения, наметившее основные перспективные тенденции в эволюции государственности, которые в той или иной мере воплощались на практике в XIX–XX веках. Методологической основой для комплексного рассмотрения исследований того периода послужил системный подход и сравнительный анализ причин и последствий достижений тех лет для современности и ближайшего будущего XXI века. Научной новизной данного исследования*

является показ комплексности теоретического наследия эпохи Просвещения для общей истории управленческо-коммуникационных идей. Представлен анализ взглядов и воззрений мыслителей конца XVII – начала XVIII веков Томаса Гоббса и Джона Локка, отстаивающих право на свободу коммуникации и либерализацию взаимоотношений в системе: "человек – общество – государство", связанных с их своеобразным пониманием роли государственного управления. Французские просветители Франсуа Вольтер, Дени Дидро, Жан Д'Аламбер, Этьенн Кондильяк были гораздо меньшими теоретиками в управленческо-коммуникационных вопросах, но их успешная эпистолярная и энциклопедическая коммуникационная практика, начиная с третьего десятилетия XVIII века, значительно повысила самосознание масс. Показано влияние их идей на возможность прогрессивного развития социальных взаимоотношений, на улучшение управляемости национальных государств и на то, как ученые нового типа смогли не только популяризировать знание, но и практически сделать его предметом общественной коммуникации. В этом контексте рассмотрено значение политико-правовых проблем коммуникации в видении Шарля Луи Монтескье и проанализированы идеи республиканского управления Жан-Жака Руссо как выдающегося деятеля Просвещения, придававшего большое значение формам и методам формирования структур управления государством. В завершение рассматриваемого исторического периода представлен сравнительный исторический анализ наиболее значимых высказываний таких мыслителей, как Иммануил Кант и Георг Вильгельм Фридрих Гегель. Эти основоположники научного дискурса вокруг проблем власти и государства, войны и мира, эффективности государственного управления и коммуникации во взаимоотношениях с народом заложили непреходящие основы теоретической аргументации двух противоположных воззрений на кардинальную проблему современности – возможность или невозможность достижения взаимоприемлемых основ нового мирового порядка мирным путём, исключающим все виды гибридных войн. Дана общая картина научно-технических достижений данного периода, влияющих на уровень понимания управленческо-коммуникационных функций государства того времени в сопоставлении с современностью.

Ключевые слова: *власть; государство; государственное управление; коммуникация; сравнительный исторический анализ*

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The beginning of the soviet theoretical archaeology: theoretical studies at the Institute of archaeology AS UkrSSR in the 1960s

Abstract. *The article is dedicated to an exploration of archaeological theory issues at the Institute of archaeology AS UkrSSR in the 1960s. This period is one of the worst studied in the history of Soviet archaeology. But it was the time when in the USSR archaeological researches reached the summit, quantitative methods and methods of natural sciences were applied and interest in theoretical issues had grown in archaeology. Now there are a lot of publications dedicated to theoretical discussions between archaeologists from Leningrad but the same researches about Kyiv scholars are still unknown. The archaeological theory includes both generalizations made on the basis of archaeological sources and archaeological methodology. The article emphasizes the history of methodology studies at the IA AS UkrSSR during the mentioned period. The research is based on evidence from the annual reports on a work of the Institute from the Scientific archive of the Institute of Archaeology NASU. According to the documents the theory was mentioned in the early 1950s because of publication of new J. V. Stalin's works. However, that time as well as at the beginning of the next decade, when works started under three volumes of "The Archaeology of the UkrSSR", it was written that attention to theoretical issues was focused at the Institute, not enough. At the IA AS UkrSSR discussions on archaeological methodology started in the 1960s when papers on theoretical issues, applying cybernetic, methods of natural sciences and statistical methods into archaeology were regularly presented at sessions of the Academic council. Yu. N. Zakharuk was the most active employee of the Institute who worked in this field. In addition to presentation of papers at conferences, and sessions of the Academic council and publications, he was an executor of the scheduled work 'Methodological and methodic issues of archaeological science' in 1968–1970. Also it was planed to publish a book on theoretical issues. In other words, the IA AS UkrSSR was the first archaeological establishment in the USSR where the work on archaeological methodology was scheduled. According to circumstances this work had not been completely finished but the Ukrainian scholar was invited to hold the position of deputy director at the Institute of Archaeology AS USSR in Moscow. Despite a skeptical attitude to the theory among most Soviet*

archaeologists Yu. N. Zakharuk was able to intensify the work on theoretical issues in Soviet archaeology. A separate theoretical session, which was organized by him at the Plenum of the IA AS USSR in Moscow in 1972, might be considered as an initialization of theoretical archaeology as a new sub-discipline in the USSR.

Keywords: *history of archaeology; archaeological theory; institutional history; Ukrainian archaeology; Yu. N. Zakharuk; 1960s*

Introduction.

The post-war period is one of the worst studied in the history of Soviet and Ukrainian archaeology. While a lot of articles and dozens of books are dedicated to the archaeology of the Russian Empire and the interwar Soviet archaeology, there are only scanty publications on the history of the Soviet archaeology of the 1950s – 1980s. But it was the time when Soviet archaeology, including its Ukrainian branch, reached the summit. During this period hundreds of archaeological expeditions were working in the whole country and dozens were active in the UkrSSR, quantitative methods and methods of natural sciences were applying into practice and a lot of fundamental publications dedicated to different periods of ancient history appeared in print. In the early 1970s the Soviet theoretical archaeology, which was a sub discipline and unique phenomenon had existed till the beginning of the 1990s, institutionalized in the USSR. The author defines it as a special branch of archaeology studies archaeological cognition (Paliienko, 2015, p. 392).

This topic has not been studied enough by historians of science. The period of the 1960s, when the Soviet theoretical archaeology engendered, is still a lacuna. There is information about theoretical archaeologists from Leningrad and their discussions of that time, while it is unknown what happened in Kyiv during this period and what role Ukrainian scholars, especially Yu. N. Zakharuk, played in the formation of the new tendency.

There have been no special monographs on the period of the 1960s yet but this topic is overviewed within the context of the history of Soviet archaeology by Leo Klejn in his book ‘The Phenomenon of Soviet Archaeology’ (Klejn, 1993). Later it was updated by the author and translated into a few foreign languages including English (Klejn, 2012). But Leo Klejn worked in Leningrad and did not know what had happened at that time in Kiev. That’s why he paid particular attention to the work of central archaeological establishments such as the Institute of archaeology AS USSR (the IA AS USSR) and its Leningrad branch (the LBIA AS USSR). This book is based on Leo Klejn and coauthors’ article published in English in one of the western journals even in the early 1980s (Bulkin, Klejn, & Lebedev, 1982). In this publication the period of the 1960s is outlined only in a general way and the development of archaeology in the UkrSSR is not touched. Nevertheless, the article became the main source of information on Soviet archaeology for western researchers. For example, B. Trigger referred to it in his “A History of Archaeological Thought” which has a few editions (Trigger, 1989; Trigger, 2006). Biographies of the Soviet archaeologists working in the

post-war period were also examined in other Leo Klejn's book (Klejn, 2014) but Yu. N. Zakharuk is not mentioned there.

Special books dedicated to the history of the main archaeological research establishments such as the Institute for the history of material culture RAS (former the LBIA AS USSR) (Nosov, 2013), the Institute of Archaeology NAS of Ukraine (Tolochko (Eds.), 2015) and the Institute of Archaeology RAS (Makarov, 2019) had been published during the last eight years. The Ukrainian edition has an outline chapter on a history of the Institute including its development in the 1950s and 1960s (Abashyna & Kolesnykova, 2015, pp. 42–52). But theoretical researches of that time are not overviewed there as well as Yu. N. Zakharuk's biography included to the book contains almost no information about his works on theoretical issues in the late 1960s (Liashko & Videiko, 2015) and has factological inexactitudes.

My numerous articles are dedicated to separate aspects of the Soviet theoretical archaeology history but they cover only the period of the 1970s and 1980s. One of them, in particular, reveals the role of Yu. N. Zakharuk in the process of organization of the theoretical section at the IA AS USSR Plenum dedicated to results of field researches in 1971 (Paliienko, 2017). Another article deals with a history of Kiev center of theoretical archaeology in the late 1970s and the middle 1980s (Paliienko, 2016).

Thereby, the development of theoretical researches in the 1960s at the Institute of Archaeology AS UkrSSR and Yu. N. Zakharuk's activity in this field are still unexplored. And the aim of the current article is to fill this gap.

Theoretical background and sources of the research.

It has to be emphasized that notions "theory" and "theoretical knowledge" were used in two aspects in the post-war Soviet archaeology. This problem was analyzed in detail by Vladimir Gening who was one of the leading archeological theorists of that period. He highlighted the concrete archaeological theoretical knowledge or the AT-knowledge which reveals regularities of a studying object and includes a source study and different kinds of descriptions of ancient societies history and logical and methodological knowledge or the archaeological methodological theory (the AM-theory) which realizes different methodological functions in the research process (forming of logical apparatus, the rules of knowledge extraction) and provides production of the AT-knowledge (Gening, 1989, pp. 122–128).

In the Soviet archaeology of the 1950s and the early 1970s the notion "theory" was applied in the first aspect as historical generalizations made on the base of archaeological sources. And later I will overview this topic separately. This article emphasizes on the archaeological methodology which includes definition of the main archaeological notions and issues of typology and classification because the work on these problems initialized the process of the Soviet theoretical archaeology forming in the 1960s.

The research is based on information from the annual reports on a work of the IA AS UkrSSR (1946–1971) from the Scientific archive of the Institute of Archaeology

NASU, the fund No. 62, descriptions No.No. 1 and 1-additional (SA IA NASU. F. 62. D. 1 and 1-ad.). The letter (Zakharuk, 1971, August 16) from the correspondence between Yu. N. Zakharuk and Leo Klejn from Klejn's personal archive is a source to characterize Kiev archaeologists' attitude to archaeological theory. It was allowed to make a photocopy of it which is stored now at the author's personal archive. "The report on a work of the IA AS USSR in 1971" from the Archive of the Russian Academy of science, fund No. 1909, description No. 1 (ARAS. F. 1909. D. 1) contains information on Yu. N. Zakharuk's activity after his transfer to the IA AS USSR. Information from these sources is enough to reveal the current issue.

Results of the research.

After WW2 the theory as historical generalizations made on the base of archaeological sources was mentioned at the IA AS USSR at the turn of the 1940s and the 1950s. It was caused by the publication of J.V. Stalin's work "Marxism and Problems of Linguistics" in 1950. It is particularly written in the chapter describing shortcomings of the research establishment of the report on work of the Institute in 1950:

- Generalized topics touching upon significant theoretical issues suggested in J. V. Stalin's work "Marxism and Problems of Linguistics" on the basis of archaeological sources were not elaborated.
- The Institute had not published any critique of N. Ya. Marr's concepts in archeology and bourgeois theories on the issues of the Slavs genesis.
- There were no discussions on important theoretical issues of archaeology and ancient history (SA IA NASU. F. 62. D. 1-ad. C. 1950/3. S. 12).

The theory was recalled again in the early 1950s because of resolutions of the 19th Congress of the C. P. S. U. and publication of another J. V. Stalin's work "Economic Problems of Socialism in the USSR". To eliminate the flaws and to improve the Institute work it was decided "*to organize a wide discussion of a few actual theoretical issues of archaeological science*" in 1953 (SA IA NASU. F. 62. D. 1-ad. C. 1952/2. S. 12). But any details on this event have not been found in the archival sources.

Then for a few years the theory or discussions on theoretical issues were not mentioned in the annual reports on the work of the IA AS UkrSSR at all. This topic was resumed only at the edge of the next decade.

In the early 1960s insufficient attention to theoretical issues was figured as one of the main shortcomings of the establishment functioning in the reports on the IA AS UkrSSR work and the inspection reports on its research activity, though emphasizes might differ. So it is written in the Inspection report from 1960 that there were less works solving significant theoretical issues in the Institute plan and its administration did not struggle enough against descriptive approach in works of employees (SA IA NASU. F. 62. D. 1-ad. C. 1960/1. S. 38). Authors of the report on works in 1961 highlighted a lag in development of theoretical and methodical issues of archaeology among other shortcomings which was explained by flaws of the Academic

council work. A recommendation to it was to discuss papers on archaeological theory and methodology on meetings, especially, in the light of making a summarizing work "The Archaeology of the UkrSSR". Moreover, the intensification of theoretical researches on issues of ethnical attribution of archaeological cultures and ethnogeny issues in general was referred to the immediate tasks of the Institute (SA IA NASU. F. 62. D. 1-ad. C. 1961/5. S. 29–30). Apparently, the theory mentioned there means historical generalizations made on the base of archaeological sources. The commission of inspectors controlling the work of the IA AS UkrSSR in 1961 accepted the conclusion on the lag in development of theoretical and methodical issues of archaeology caused by flaws of the Academic council work. But also it noted that recently the Institute had advanced discussing theoretical issues on meetings which had to go on. And it was significant to provide a theoretical attainment of research fellows, especially, young people. In addition, it was recommended to disclose reactionary and bourgeois theories in archaeology more fearlessly (SA IA NASU. F. 62. D. 1-ad. C. 1961/5. S. 37–41).

A small amount of theoretical paper presented on meetings of the Academic council and insufficient attention to special theoretical elaboration of large-scale scientific issues were figured among shortcomings of the Institute in the report of 1962 (SA IA NASU. F. 62. D. 1-ad. C. 1962/2. S. 26–27). There as well as in the next year report it was recommended to inculcate theory liking to young research fellows which had to be an aim of the methodological workshop of the Institute (SA IA NASU. F. 62. D. 1-ad. C. 1963/1. S. 35).

But was it really so bad with archaeological theory at the IA AS UkrSSR during this period? And what caused the activation of works on this topic in the early 1960s? Apparently, it was linked with the start of works under three volumes of "The Archaeology of the UkrSSR' and making of 'The Corpus of Archaeological Sites of the UkrSSR'. As it was written in the Report, the realization of these works contributed to deep elaboration of significant theoretical and source studying issues in the field of archaeology (SA IA NASU. F. 62. D. 1-ad. C. 1960/1. S. 31).

However, we have to highlight a certain activation of the development of completely methodological topics. Papers dedicated to them were regularly discussed at meetings of the Academic Council of the IA AS UkrSSR over the period of the 1960s. For example, in 1961 Yu. N. Zakharuk presented his paper "Certain issues of theory and methodology of archaeological research" dedicated to the category "archaeological culture" at one of these meetings (SA IA NASU. F. 62. D. 1-ad. C. 1961/5. S. 25). We may consider this event as a beginning of the discussion on this topic at the Institute besides this had happened earlier than the discussion on the definition of the note "archaeological culture" reached all-Union scope. This Yu. N. Zakharuk's paper underlay his article "Problems of Archaeological Culture" (Zakharuk, 1964) which was widely debated by other discussants in the late 1960s.

The papers related to issues of theory, methodology of archaeological research and applying methods of natural and technical sciences in archaeology were actively

presented again at meetings of the Academic Council in 1963. Thus A. A. Beletskii's paper "On the Comparative-Historical Method in the Historical-Archaeological Research" was discussed in April, 2, K. V. Shishkin's paper "Applying of the Aerial Photography in Archaeology" was debated in April, 11. N. V. Ryndina, a research fellow of the department of archaeology of Moscow State University (MSU) read her paper "Metallography in Archaeology" at the meeting in May, 10 (SA IA NASU. F. 62. D. 1-ad. C. 1963/1. S. 29–30). In other words, all of these papers were methodical.

In the middle of the decade applying of cybernetic and mathematical statistic in archaeology was debated at the Institute. On the 1st of February 1965 the paper "Cybernetic in Archaeology" was discussed at the meeting of the Academic Council (SA IA NASU. F. 62. D. 1. C. 564. S. 28) and almost in two years, on the 18th of April 1967 D. V. Deopic, the head of the laboratory of the application of statistical method in social sciences, an associate professor of MSU presented his paper "Techniques, methods and experience of applying of the statistic analysis of archaeological sources".

On the 13th of June 1967 Yu. N. Zakharuk's paper "On the methodology of archaeological science and its problems" was discussed at the meeting of the Academic Council (SA IA NASU. F. 62. D. 1. C. 626. S. 22). After this event a new topic on archaeological methodological issues and application of new methods of natural and technical sciences to archaeology was scheduled to the Institute plan of subjects in 1968 and it was planned to complete a monograph on this topic till the centenary of V.I. Lenin's birth (SA IA NASU. F. 62. D. 1. C. 626. S. 23–24). Yu. N. Zakharuk was personally an executive of the topic "Methodological and Methodical Issues of Archaeological Science" in the context of the issue "A History of World Culture". The aim of the work was a theoretical elaboration of significant methodological problems and new tendencies in archaeology including writing the book on theoretical issues and making experiments on application of natural sciences methods such as the spectral analysis of metal items and the methods of geophysical survey of archaeological sites. The staff of the laboratory of archaeological technology, which was just organized at the Institute at that time, was responsible for the experimental part.

In future I will dedicate a single article to the applying of methods of natural sciences at the Institute of archaeology AS UkrSSR. As to the book on methodological issue it had to have the next structure:

- Chapter "Issues of the Terminology and Conceptual Apparatus of Archaeological Science" – 1 quire.
- Chapter "Methodological Issues of Archaeological Culture" – 1,5 quire.
- Chapter "Archaeology in the System of Social Sciences" – 1 quire.
- Chapter "Ways of the Development of Methodology of Archaeological Science" – 1 quire.
- "Introduction and Conclusion" – 1 quire (SA IA NASU. F. 62. D. 1. C. 704. S. 8–9).

But in fact, Yu. N. Zakharuk had completed only the second and the third chapters. He planed to write the first chapter in 1969 but this work was not finished

because of a long illness of the author (SA IA NASU. F. 62. D. 1-ad. C. 1969/1. S. 19). In 1970 Yu. N. Zakharuk was doing the additional task to make the chapter "Tribes of the Chalcolithic age" for the volume 1 of "The History of the Ukrainian SSR" (2,5 quires) instead of the work on the scheduled theoretical topic. Taking into account that the total volume of works completed by Yu. N. Zakharuk in that year was 5 quires the Academic Council resolved to consider that the methodological topic had been finished according to the volume and to give Yu. N. Zakharuk an opportunity to end the rest of the chapters later (SA IA NASU. F. 62. D. 1. C. 704. S. 8–9). But in 1971 the scholar was transferred to the Institute of archaeology AS USSR in Moscow.

In addition to his participation at meetings of the Academic Council of the IA AS UkrSSR and works under the scheduled methodological topic Yu. N. Zakharuk presented papers at scientific conferences and published articles on issues of theory and methodology of archaeology in the 1960s. So, he presented the paper "Archaeological Culture (Certain Issues of Theory and Methodology of Research)" at the 11th scientific conference of the IA AS UkrSSR dedicated to the results of archaeological researches in Ukraine in 1960-1961 (SA IA NASU. F. 62. D. 1-ad. C. 1962/2. S. 13) and the paper "Lenin's Theoretical Legacy and Certain Issues of the Development of Archaeological Science" at the Anniversary plenum of the IA AS USSR in Leningrad in 1969 (SA IA NASU. F. 62. D. 1-ad. C. 1969/1. S. 42). The scholar published the next articles in the journal "Arkheolohiia" [Archaeology]: "Problems of Archaeological Culture" (Zakharuk, 1964), "Certain Methodological Issues in Archaeological Science" (Zakharuk, 1970a) and "Towards the Development of Theoretical Grounds of Archaeology" (Zakharuk, 1971); the next articles in the journal "Sovetskaya arkheologiya" [Soviet Archaeology]: "On the Methodology of Archaeological Science and its Problems" (Zakharuk, 1969) and "Lenin's Theoretical Legacy and Certain Issues of the Development of Archaeological Science" (Zakharuk, 1970c); as well as the article "Lenin's Theoretical Legacy in Archaeological Science" (this name of the article is mentioned in the Report) in the collection of papers "Lenin's Ideas in the Study of the History of Primitive Society, Slavery and Feudalism" where its name is a little bit differ – "Lenin's Theoretical Legacy and Archaeological Heritage" (Zakharuk, 1970b).

Besides Yu. N. Zakharuk's works, the issues of paleoeconomical modeling in archaeology were revealed in S. N. Bibikov's articles (Bibikov, 1967; Bibikov, 1969) in the late 1960s.

But in general, a skeptical attitude toward the theory was spread among most of Soviet archaeologists and the situation with this in Kyiv was not better. Working at the IA AS UkrSSR Yu. N. Zakharuk mentioned this problem in his letter to Leo Klejn in the early 1970s:

"*Alas, unfortunately, not all share the view on the decisive role of this type of works on the contemporary stage of development of our science. It is especially unsightly on this point there, in Kiev the majority of archaeologists, moreover, the overwhelming majority has an extremely skeptical or even ironic attitude to the works*

of this type. A small part, mainly, of young workers, in turn, has quite often very simplified and "lite" idea on structure, tasks and ways of theoretical problems elaboration" (*Zakharuk, 1971, August 16).*

However, the necessity to develop such topics was determined by objective factors, in particular, a need to define the main notions of archaeology and to formalize the procedure of primary processing of archaeological sources and the methodic of ethno-social and socio-historical reconstructions was caused by attempts to apply cybernetic methods into archaeology.

An academician B. A. Rybakov being the director of the IA AS USSR, which was the main archaeological establishment of the USSR, invited Yu. N. Zakharuk to hold the position of deputy director on science and to intensify theoretical work. The transfer of the researcher to Moscow enabled to give an impetus to the work on theoretical issues. In 1971 he presented the paper "Theoretical Grounds of Archaeology" at the meeting of the Academic council of the IA AS USSR (ARAS. F. 1909. D. 1. C. 1013. S. 24) but the most important is that Yu. N. Zakharuk exercised his authority to organize the work of the separate theoretical session at the annual Plenum of the IA AS USSR for the first time in the Soviet Union. Its work at the Plenum of the IA AS USSR on results of the field season in 1971 (Moscow, 1972) might be considered as an institualization of the new subdiscipline which is theoretical archaeology. The discussion on the definition of the object and subject matter of archaeology started at the same time continuing till the early 1990s.

Conclusion.

So the theory as historical generalizations made on the basis of archaeological sources was mentioned in the IA AS Ukr.SSR in the early 1950s because of publication of new J.V. Stalin's works and the resolutions of the 19th Congress of the C. P. S. U. A. lack of discussion on important theoretical issues of archaeology was figured in the reports as one of the Institute's shortcomings. This problem was recalled again at the turn of the 1950s and the 1960s. The lack of attention to theoretical issues at the IA AS UkrSSR was highlighted in the reports. Apparently, the actualization of this issue was linked with the start of works under three volumes of "The Archaeology of the UkrSSR".

Discussions on archaeological methodology started at the IA AS UkrSSR in the early 1960s. For the decade papers on theoretical and methodological issues, applying cybernetic, methods of natural sciences and statistical methods into archaeology were regularly presented at sessions of the Academic council.

Yu. N. Zakharuk was one of the Institute employees who presented his theoretical papers. In 1968–1970 he was an executor of the scheduled work "Methodological and Methodical Issues of Archaeological Science" a result of which had to be the theoretical book publishing. But this work had not been completely finished according to circumstances. Also, this scholar presented theoretical papers at conferences and prepared a few articles in this field for the decade. In the late 1960s, the issues of

paleoeconomical modeling in archaeology were revealed in S. N. Bibikov's articles. But in general, the IA AS UkrSSR staff showed a skeptical attitude toward the theory as well as the same attitude was spread among the most of Soviet archaeologists.

Thereby, the IA AS UkrSSR was the first archaeological establishment in the USSR where the work on archaeological methodology was scheduled in the late 1960s. And Yu. N. Zakharuk was invited to hold the position of deputy director at the Institute of Archaeology AS USSR in Moscow where he was able to intensify the work on theoretical issues in Soviet archaeology. The separate theoretical session, which was organized by him at the Plenum of the IA AS USSR in Moscow in 1972, might be consider as an institualization of the Soviet theoretical archaeology as a new subdiscipline and appearance of the unique phenomenon in the USSR.

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Біля витоків Радянської теоретичної археології: теоретичні дослідження в ІА АН УРСР в 1960-і роки

Анотація. *Стаття присвячена вивченню питань археологічної теорії в Інституті археології АН УРСР в 1960-і роки. Даний період є одним з найменш вивчених у історії радянської археології. Однак саме тоді археологічні дослідження у СРСР досягли значних масштабів, почалося широке впровадження методів природничих і математичних наук, виник інтерес до теоретичних проблем. І якщо про теоретичні дискусії серед археологів*

Ленінграда в цей період уже написано багато, то про розробку подібних питань у Києві нічого не відомо. Під археологічної теорією зазвичай розуміють як узагальнення на основі археологічних матеріалів, так і археологічну методологію. У даній статті головний акцент зроблено саме на історії дослідження методологічних проблем в ІА АН УРСР у зазначений період, що вивчається на основі відомостей з щорічних звітів про роботу Інституту з Наукового архіву ІА НАН України. Документи свідчать, що про теорію в Києві заговорили ще на початку 1950-х рр., у зв'язку з виходом нових праць Й. В. Сталіна. Правда, тоді, як і потім на початку наступного десятиліття, але вже у зв'язку з початком роботи над тритомною "Археологією УРСР", вказувалося, що теоретичним питанням в Інституті приділяється мало уваги. Обговорення ж проблем археологічної методології в ІА АН УРСР почалося вже в 1960-і роки, зокрема, на засіданнях Вченої ради регулярно заслуховувалися доповіді з питань археологічної теорії, впровадження в археологію методів природничих наук, застосування кібернетики та методів математичної статистики. Найбільш активно в даній області працював співробітник ІА АН УРСР – Ю. М. Захарук, який крім доповідей на Вченій раді та конференціях, публікації статей у 1968 – 1970 рр. також був виконавцем планової теми "Методологічні та методичні проблеми археологічної науки", у рамках якої планувалося написання монографії з проблем теорії. Тобто ІА АН УРСР був першою археологічною науковою установою у СРСР, де в той період робота над методологічними проблемами була включена до плану. І хоч ця тема в силу певних обставин повністю завершена не була, але український учений був запрошений на роботу до Москви в ІА АН СРСР. І, не дивлячись на скептичне ставлення до теорії серед більшості радянських археологів, Ю. М. Захаруку вдалося активізувати роботу над питаннями археологічної методології в СРСР, а організовану їм окрему теоретичну секцію на московському Пленумі ІА АН СРСР у 1972 році можна вважати інституціолізацією в Радянському Союзі теоретичної археології в якості нової субдисципліни.

Ключові слова: *історія археології; археологічна теорія; українська археологія;інституціональна історія; Ю. М. Захарук; 1960-і роки*

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У истоков Советской теоретической археологии: теоретические исследования в ИА АН УССР в 1960-е годы

Аннотация. *Статья посвящена изучению вопросов археологической теории в Институте археологии АН УССР в 1960-е годы. Данный период является одним из наименее изученных в истории советской археологии. Однако*

именно тогда археологические исследования в СССР достигли значительных масштабов, началось повсеместное внедрение методов естественных и математических наук, возник интерес к теоретическим проблемам. И если о теоретических дискуссиях среди археологов Ленинграда в этот период уже написано много, то о разработке подобных вопросов в Киеве не известно ничего. Под археологической теорией обычно понимают как обобщения на основе археологических материалов, так и археологическую методологию. В данной статье главный акцент сделан именно на истории исследования методологических проблем в ИА АН УССР в указанный период, которая изучается на основе сведений из ежегодных отчётов о работе Института из Научного архива ИА НАН Украины. Документы свидетельствуют, что о теории в Киеве заговорили ещё в начале 1950-х, в связи с выходом новых трудов И. В. Сталина. Правда, тогда, как и потом в начале следующего десятилетия, но уже в связи с началом работ над трёхтомной "Археологией УССР", указывалось, что теоретическим вопросам в Институте уделяется мало внимания. Обсуждение же проблем археологической методологии в ИА АН УССР началось уже в 1960-е годы, в частности, на заседаниях Ученого совета регулярно заслушивались доклады по вопросам археологической теории, внедрения в археологию методов естественных наук, применения кибернетики и методов математической статистики. Наиболее активно в данной области работал сотрудник ИА АН УССР – Ю. Н. Захарук, который помимо докладов на Ученом совете и конференциях, публикации статей в 1968 – 1970 гг. также являлся исполнителем плановой темы "Методологические и методические проблемы археологической науки", в рамках которой планировалось написание монографии по проблемам теории. То есть ИА АН УССР был первым археологическим научным учреждением в СССР, в котором в тот период работа над методологическими проблемами была включена в план. И хоть данная тема в силу определённых обстоятельств полностью завершена не была, но украинский учёный был приглашен на работу в Москву в ИА АН СССР. И, не смотря на скептическое отношение к теории среди большинства советских археологов, Ю. Н. Захаруку удалось активизировать работу над вопросами археологической методологии в СССР, а организованную им отдельную теоретическую секцию на московском Пленуме ИА АН СССР в 1972 году можно считать институционализацией в СССР теоретической археологии в качестве новой субдисциплины.

Ключевые слова: *история археологии; археологическая теория; украинская археология; институциональная история; Ю. Н. Захарук; 1960-е годы*

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The legacy of Saint Luke (Valentin Felixovich Voyno-Yasenetsky) to medical sciences

Abstract. *Saint Luke, Archbishop of Simferopol and Crimea (1877–1961), was born Valentin Felixovich Voyno-Yasenetsky in Kerch, Crimea. He served as an outstanding physician and Academic Professor of Topographic Anatomy and Operative Surgery at Medical School of Tashkent University. He worked extensively on the fields of surgery, regional anesthesia, pyogenic infections, ophthalmology, neurosurgery, oncology, orthopedics, otorhinolaryngology, gynecology, urology, and dentistry, often under difficult circumstances. He performed a wide variety of operations, from minor outpatient procedures to extremely complicated ones, followed by extensive inpatient management and treatment of ailing individuals. He published numerous research articles and books. His most acclaimed monograph entitled "Essays on the surgery of pyogenic infections" ("Sketches of purulent surgery"), focused on the broad field of surgery with special reference to the pyogenic infections and served as a reference tool and guide book for the next generations of physicians. The Stalin Prize was the highest professional honor awarded to Valentin Felixovich Voyno-Yasenetsky by the Soviet state in recognition of his contribution to science. Voyno-Yasenetsky was a blessed physician who had a major influence on both patients and colleagues, due to his fundamental ethical principles and values based on Christian beliefs. His life and scientific work have been an example of the practical unity of scientific truth and religious faith. He was ordained to the diaconate and priesthood, until he elevated to the ranks of Bishop and Archbishop. He was arrested and subsequently exiled for his religious beliefs and his glorification by the Orthodox Church as Saint Luke was held in Russia in 2000, as a recognition of God's holiness manifesting in his life. Saint Luke received an honorable place in the history of*

Medicine and the Eastern Orthodox Church. The present study aims to highlight key elements of his life and his scientific contributions.

Keywords: *Saint Luke; Voyno-Yasenetsky; medicine; science; Simferopol*

Introduction.

Saint Luke, Archbishop of Simferopol and Crimea (1877–1961), was born Valentin Felixovich Voyno-Yasenetsky (Валентин Феликсович Войно-Ясенецкий (in Russian)) in Kerch (Antonopoulos, 2017, p. 23), one of the most ancient cities of Crimea, originated in the 6th century BC as the Greek colony of Panticapaeum (Kubijovyč, 1988) (Fig. 1). Valentin was the third of five children (Pavel, Olga, Valentin, Vladimir and Victoriya) of a pious Catholic pharmacist father (Felix Stanislavovitch Voino Yassenesco, Феликс Станиславович Войно-Ясенецко (in Russian)) and an Orthodox mother (Mariya Dmitriyevna, Мария Дмитриевна (in Russian)). Although the Voyno-Yasenetskys were a powerful family and several generations worked traditionally at the Polish and Lithuanian courts, his family had adopted a simple and humble way of living (Popovsky, 1979; Baloyannis, 2015; Begiev, Begiev, & Yakovleva, 2020).

Figure 1. Valentin Felixovich Voyno-Yasenetsky (1877–1961) (Antonopoulos, 2017, p. 68).

He began his elementary education at Kiev's high school and University of Law, then moved to Munich to continue his studies at the School of Fine Arts, and finally he graduated with honors from the Great Prince St. Vladimir Medical School of the University of Kiev (Baloyannis, 2015; Andreev & Ostroushko, 2017). After receiving his secondary education, Voyno-Yasenetsky enhanced his knowledge and expertise in

the art of painting, although he never completed art studies (Antonopoulos, 2017, p. 30). Thus, during his introductory session and evaluation examination at the Saint Petersburg Academy of Arts, he understood that his true calling was to relieve pain from suffering people by studying the art of medicine (Kaladze, 2016).

After his graduation from the Medical School of the University of Kiev, he served as an outstanding physician and Academic Professor of Topographic Anatomy and Surgery (Baloyannis, 2015; Andreev & Ostroushko, 2017). As a surgeon he was the founder of purulent surgery performing several procedures and describing key anatomical landmarks as well (Morgoshiya & Apchel, 2018). His research interests involved surgery and anatomy with emphasis on the development of surgical and anesthesia methods, organ transplantation, treatment of pyogenic infections, wounds, osteomyelitis, and several systemic abnormalities (Baloyannis, 2015; Ditkovskaia, 2017). His scientific work includes 55 research articles and books, covering the period from 1908 to 1956, while he was awarded the State Stalin Prize in Medicine in 1946 (Baloyannis, 2015; Andreev & Ostroushko, 2017).

Voyno-Yasenetsky was married to Anna Vasilievna Lanskaya (Анна Васильевна Ланская) and had four children (Michael, Helen, Alexios and Valentine). Anna Lanskaya was a gentle and moral nurse who served in the Kiev Military Hospital and in Russo-Japanese war and died from pulmonary tuberculosis (Antonopoulos, 2017, pp. 83–85). According to the doctrines of the Orthodox Church, their children were treated with love, decency, and respect, whereas all of them studied in Health Sciences including Medicine, Epidemiology and Biology (Baloyannis, 2015).

Voyno-Yasenetsky was an eminent and powerful person who had a major influence on both patients and colleagues, due to his fundamental ethical principles and values based on Christian beliefs and philosophy (Ditkovskaia, 2017). He was ordained to the diaconate and priesthood, until he elevated to the ranks of Bishop and Archbishop. He was arrested and subsequently exiled for his religious beliefs twice to the Krasnoyarsk region of Eastern Siberia and once to the shores of the White Sea (Popovsky, 1979). His glorification by the Orthodox Church as Saint Luke was held in Russia in 2000, as a recognition of God's holiness manifesting in his life (Andreev & Ostroushko, 2017).

Following the adoption of new scientific innovations, medical ethics and high moral principles deriving from his religion, Valentin Felixovich Voyno-Yasenetsky received an honorable place in the history of Medicine and the Eastern Orthodox Church (Mylantyeva, Nebylitsin, & Pipipayt, 2010). His life and scientific work have been an example of the practical unity of scientific truth and religious faith (Kozovenko, 2015). The aim of the present study aims to highlight key elements of Voyno-Yasenetsky's life and scientific work and his contribution to Medical Sciences.

Theoretical Foundations.

An overview of Voyno-Yasenetsky's life and scientific work was based on specific historical, biographical, and scientific sources, included in relevant published

studies. Based on this specific knowledge base, and by summarizing, aggregating, organizing, comparing and finally evaluating and highlighting the key points of the evidence extracted from the used literature, the results including three principal sections (medical career and surgical contributions, research interests, and spiritual life), the discussion and conclusions of the current study, contribute to existing knowledge.

Results and discussion.

1. Medical career and surgical contributions.

As a medical student Voyno-Yasenetsky received significant skills in the areas of surgery, microbiology, ophthalmology and orthopedics during his training. Thus, during his education he was able to identify some of the common etiological agents responsible for causing pyogenic infections by observing microorganisms under the light microscope, to make early and accurate diagnosis of ocular comorbidities and executing routine orthopedic and surgical procedures following aseptic guidelines (Shevchenko, 2011, pp. 19–38). After completing his graduation from Medical School in 1903 and during the World War I, Voyno-Yasenetsky obtained surgical experience as a member of the Kiev Medical Hospital of the Red Cross (Baloyannis, 2015), serving as a surgeon and chief physician of the infirmary for the injured soldiers and also started working as a provincial doctor in the hospitals of Simbirsk, Kursk, Saratov and Vladimir regions (Morgoshiia, 2019; Begiev, Begiev, & Yakovleva, 2020). He also gained considerable experience in ophthalmology, serving at Kiev's Eye Clinic (Kaladze, 2016).

Working alone in small hospitals of rural areas, including Ardatov, Fatezh, Liubazh, and Pereslavl-Zalessky he performed a thousand procedures every year (Popovsky, 1979; Kaladze, 2016) (Fig. 2). In 1917, he was appointed surgeon-in-chief at the Tashkent General Hospital, and in 1919 he was elected Professor of Topographical Anatomy and Operative Surgery at Medical School of the newly established Tashkent University (Baloyannis, 2015; Morgoshiya & Apchel, 2018). He worked as a surgeon in Bolshaya Murta, Krasnoyarsk Krai, from 1937 until 1941 (Andreev & Ostroushko, 2017), and during this period he was performing about five to six major operations a day, under very difficult circumstances, without eating properly or looking after himself. However, his letters from Krasnoyarsk during this period are full of happiness, hope and faith, because nothing could be comparable with his great scientific destination (Popovsky, 1979). At the end of his career, and after serving in the Great Patriotic War, he was assigned to the Army Hospital and Hospital of Veterans, in Simferopol of Crimea, as chief surgeon and consultant (Kosachev, Gladkikh, & Iakovlev, 2011; Baloyannis, 2015).

Voyno-Yasenetsky made magnificent contributions not only to the field of surgery and pyogenic infections, but also to anesthesiology, ophthalmology, neurosurgery, oncology, orthopedics, otorhinolaryngology, gynecology, urology and dentistry (Mylantyeva, Nebylitsin, & Pipipayt, 2010). He performed a wide variety of

operations, from minor outpatient procedures to extremely complicated ones, followed by extensive inpatient management and treatment of ailing individuals (Baloyannis, 2015). Up to that time, patients usually died not because of unsuccessful surgical interventions, but from the fact that they could not endure anesthesia. Voyno-Yasenetsky introduced a new method of regional anesthesia, which in terms of side effects was a more benign technique when compared to conventional local and general ether and chloroform anesthesia procedures (Begiev, Begiev, & Yakovleva, 2020). After extensive research, he was the first physician who provided local anesthesia in order to treat the trigeminal neuralgia, by injecting local anesthetic solution into the area where the second branch of the nerve leaves the skull through the foramen rotundum (Baloyannis, 2015).

Figure 2. Valentin Felixovich Voyno-Yasenetsky (left) performing an operation in Pereslavl-Zalessky hospital (Antonopoulos, 2017, p. 65).

Having experience in microbiology, he worked extensively on the field of bacterial and fungal pyogenic infections, treating pyogenic infections and septic wounds by using surgical procedures as the sole therapeutic method (Voino-Yasenetsky, 2011) much earlier than the antibiotic era started with the first initial observation and discovery of penicillin by Fleming in 1929 (Aminov, 2010).

He pioneered many techniques within the spectrum of surgery, including laparotomies, neurosurgical and ophthalmological (e.g. iridectomy and lacrimal sac removal using simplified local anesthesia) procedures, resection of the upper jaw, gynecological and pediatric surgical operations (Baloyannis, 2015). Besides, he gained a great reputation as a surgeon and he also received professional honor for his contribution, after his name was linked to several innovative procedures and topographic anatomical landmarks primarily undergone by him. Examples include the pelvic resection by Voyno-Yasenetsky, the Voyno-Yasenetsky operation of excision of the affected skin and fatty tissue of the axillary fossa due to multiple hidradenitis,

the original Voyno-Yasenetsky closure method of the traumatic diaphragm injury, the Voyno-Yasenetsky incision of the popliteal fossa, and the Voyno-Yasenetsky's line and point anatomical landmarks, referring to the projection and exit of the sciatic nerve at the gluteal region, respectively (Morgoshiya & Apchel, 2018; Morgoshiia, 2019).

Vonyo-Vaseyetsky's contribution to transplants was also significant. By the end of 1910s, the first kidney xenotransplant experiments in humans were performed by Jaboulay and Unger, using kidneys from domestic animals (pigs, goats) and monkey donors respectively, but all the patients died soon, since these early human kidney xenografts functioned just for a short-term period (Barker & Markham, 2013). Later, as the concept of kidney transplantation was extensively established by French and American surgeons, it was stated that renal transplantation should be more effective using organs from nonhuman species, since the availability of kidneys from humans was extremely limited and chronic hemodialysis had not been developed yet (Cooper, 2012). In 1924, at the Yeniseysk town hospital, Krasnoyarsk Krai, Voyno-Yasenetsky performed successfully the world's first kidney xenotransplantation from calf to a peasant suffering from uremia (Popovsky, 1979), while a decade later, Yurii Voronoy from Ukraine achieved the first human allograft renal transplantation (Matevossian et al., 2009).

Twelve years after performing his first splenectomy in 1911, on a patient due to a traumatic rupture who died five days later from necrosis of the large intestine, Voyno-Yasenetsky proposed a new method of spleen removal and ligation of blood vessels, as an addition to the existing data of described anatomical structure and the operation established by other scientists (Kozovenko, 2015; Morgoshiya & Apchel, 2018). With this new scientific procedure, referred as the "Voyno-Yasenetsky method", the outstanding surgeon aimed to lower the incidence rates of surgery-related deaths and complications (Kozovenko, 2015). An additional innovative modification to a generally accepted Halsted's procedure by Voyno-Yasenetsky concerned surgery after breast cancer accompanied by lymph node removal, by which he could identify underlying comorbidities including metastases and tuberculous lymphadenitis (Kozovenko, 2015). Halsted was one of the most distinguished surgeons in American medicine, who served as a professor of surgery at the Johns Hopkins hospital in Baltimore, in the late 19th century (Rutkow, 1987). After the war, Voyno-Yasenetsky contributed to rural population health by covering a wide range of procedures, including the widespread blinding trachoma (Popivanov, 2018). In such a case he operated on a whole family where the father, mother, and five of their children were blind since birth (Begiev, Begiev, & Yakovleva, 2020).

2. Research interests.

Author of 55 scientific papers and books on the fields of surgery and anatomy, Professor Voyno-Yasenetsky worked unceasingly suffering from certain underlying medical conditions, including diabetes, heart disease, gout, relapsing fever, and deteriorating vision (Popivanov, 2018). Numerous case reports and surgical

interventions were provided concisely and simply in his works, as a source of creative inspiration, accumulation of knowledge and experience (Kaladze, 2016). His research interests focused on general surgery, regional anesthesia and surgical treatment of pyogenic infections. In 1915, he published his first important scholarly work with his own illustrations in Saint Petersburg, entitled "Regional anesthesia", as part of his dissertation thesis which he successfully defended one year later in Moscow. In his dissertation, the results of his extensive surgical procedures, an overview of peripheral nerve anatomy, along with the development of new skills for the regional anesthesia in the lower limbs and performance of efficient peripheral blocks of trigeminal, sciatic and median nerves were described thoroughly. For this work, he was awarded the Chojnacki prize by the Warsaw University, granted to the best original scientific research "Blazing new trails in the field of medicine". At that time, his first clinical cases reports entitled "Elephantiasis of the face, due to plexiform neurinoma" and "Retrograde strangulated inguinal hernia" were also published (Baloyannis, 2015; Popivanov, 2018).

During one of his exile periods to the Krasnoyarsk Krai, two of his original works were published in the scientific journal "Deutsche Zeitschrift für Chirurgie" under the name Lucas Bischof, entitled "On the suturing of vessels during the removal of the spleen", and "The necessity of increasing the operation area for operations related to malignant breast tumors". Publishers used "Lucas" as the first name and "Bischof" as the surname for Bishop Luke. Due to his arrest and exile to Krasnoyarsk and Turukhansk, Voyno-Yasenetsky could not correct the inaccuracy of the German translation. This led to the belief in scientific societies of Western Europe that the surgeon Lucas Bischof, was other than Voyno-Yasenetsky. For most of the next eight decades, these achievements remained relatively unknown within Eastern scientific community (Kozovenko, 2015).

In 1934, he published his most acclaimed monograph entitled "Essays on the surgery of pyogenic infections" ("Sketches of purulent surgery"), after at least ten years of preparation. In its first three editions (1934, 1945, 1956), the monograph was released in 60,000 copies. In November 2011, the 1st volume was published for the first time in Greek by "Akritas Publications", while in October 2014 the publication was completed with the release of the 2nd volume by "Porphyra Publications", both edited by surgeon Grigorios Lakiotis and Metropolitan of Argolis Nektarios Antonopoulos (Mylonas, Poulakou-Rebelakou, & Papadopoulou, 2017). Based on a thorough and comprehensive analysis of his personal experience on surgical treatment and dissection of thousand patients and corpses in the morgue, as well as on precise knowledge of topographic anatomy and comprehensive review of the international literature, this work focused on the broad field of surgery with special reference to the pyogenic infections and served as a reference tool and guide book for the next generations of physicians (Voino-Yasenetsky, 2011; Kozovenko & Bogopolsky, 2016; Mylonas, Poulakou-Rebelakou, & Papadopoulou, 2017; Popivanov, 2018) (Table 1).

Table 1. Surgical, and clinical issues included in "Essays on the surgery of pyogenic infections".

Surgical pathology	Infectious diseases
Scalp wounds	Meningitis; Encephalitis
Phlegmon and osteomyelitis of the craniofacial skeleton	Ludwig's angina; Laryngitis; Diptheria
Skin infections; Cellulitis; Erysipelas	Pneumonia; Bronchitis
Furuncles; Carbuncles	Tuberculosis
Ocular pyogenic granulomas	Actinomycosis
Acute parotitis; Acute otitis media	Septic arthritis; Septic pericarditis
Periostitis; Osteomyelitis	Typhoid and paratyphoid fever
Inflammatory joint and bone diseases	Syphilis
Pleurisy; Lung abscess; Mastitis	Hepatitis
Infection of iliac fossa and psoitis	Influenza
Appendicitis; Peritonitis	Measles
Liver abscess; Spleen abscess	Scarlet fever; Smallpox
Lymphangitis; Sarcoma	Relapsing fever
Retroperitoneal abscess; Perianal abscess	Malaria; Amoebiasis; Leishmaniasis
Prostatitis	Schistosomiasis; Coccidiosis

Microbiological issues were also included in "Essays on the surgery of pyogenic infections" (current approved bacterial names are given in parentheses): *Staphylococcus aureus; Staphylococcus albus (epidermidis);* β-hemolytic *Streptococci; viridans Streptococci; Pneumoniococcus (Streptococcus pneumoniae); Neisseria meningitidis; Gonococcus (Neisseria gonorrhoeae); Escherichia coli;* Friedlander's bacillus *(Klebsiella pneumoniae); Proteus vulgaris; Bacillus pyocyaneus (Pseudomonas aeruginosa); Bacillus paratyphosus C (Salmonella enterica* serotype Paratyphi C); *Bacillus anthracis; Bacillus ramosus; Bacteroides fundiliformis; Mycobacterium tuberculosis; Bacillus welchii (Clostridium perfringens); Vibrio* spp.; Spirochaetae; *Entamoeba histolytica*; *Echinococcus* spp.; *Plasmodium* spp.; *Schistosoma* spp.

The first data for the book was taken from the time of the Russo-Japanese war, while Voyno-Yasenetsky was serving as a head physician and surgeon at the Military Hospital of Chita, in 1904 (Glyanzev, 2016; Antonopoulos, 2017, pp. 41–42). Regarding the atmosphere that prevailed in Europe at the beginning of 1930s, surgeons considered that this book could serve as an extremely necessary tool in anticipation of a possible war. For both "Essays on the surgery of pyogenic infections" and a monograph entitled "Late resections for infected gunshot wounds of joints", referring to his surgical achievements in the hospitals of the Krasnoyarsk territory in 1941–1944, with an emphasis on patients with severe complications of purulent joint wound

infections, he was awarded the prestigious State Stalin Prize of first degree in 1946 (Kozhevnikov, 2018; Morgoshiya & Apchel, 2018).

3. Spiritual life.

"If you try to describe my life, do not distinguish between the surgeon and the bishop. The impression that will stand out from such a separation will be inaccurate", Voyno-Yasenetsky had told to his first biographer Mark Popovsky (Shevchenko, 2011, p. 7). When performing an operation, he used to pray for a few minutes before the beginning of each one, making the sign of the Cross on each patient's body with iodine-impregnated gauzes (Mylonas, Poulakou-Rebelakou & Papadopoulou, 2017). During his adolescence he was influenced by two important spiritual incentives. The former one was the Kiev Pechersk Lavra (Kiev Monastery of the Caves), a historic Orthodox Christian monastery, where he used to paint his sketches as an art student (Antonopoulos, 2017, pp. 28–31). The latter was a copy of the Holy Bible which he had received as the most valuable gift upon graduating from high school (Baloyannis, 2015). But also living in love and faith with his family, allowed Voyno-Yasenetsky to find fulfillment in his life according to the Christian beliefs and values.

In 1921, he was ordained a deacon continuing his work at hospital, while one week later he was ordained to the priesthood by Diocesan Bishop Innokenty of Tashkent, in a difficult time for the Orthodox Church. During this period, an antireligious campaign had begun in the Soviet Union, but Fr. Valentin continued undisturbed to preach at Tashkent Cathedral (Baloyannis, 2015). In 1923 he was tonsured a monk and consecrated a Bishop Luke in honor of the Holy Apostle and Evangelist Saint Luke the Physician. During the period 1923–1943, he was captured, sent to prison, and exiled numerous times due to his Christian faith, living under harsh isolation and painful weather conditions (Kozovenko & Bogopolsky, 2016; Begiev, Begiev, & Yakovleva, 2020). For over a decade he lived painfully in Omsk, Novosibirsk, Krasnoyarsk, Yeniseysk, Turukhansk, Arkhangelsk and Bolshaya Murta, all located thousands of kilometres away from his home, and although his health was gradually worsening, he continued healing hundreds of patients, teaching the young doctors, performing surgical operations, preaching and writing both research reports and sermons (Popovsky, 1979; Baloyannis, 2015). People used to show appreciation and express their gratitude to him in several ways, asking for his blessing. Interestingly, when he moved from Turukhansk to the northernmost regions of the Arctic Ocean region, residents managed to collect warm clothes and furs for him, saving his life (Popovsky, 1979).

During the invasion of the Soviet Union by Germans, Bishop Luke asked the central government to be moved to the front and serve as a surgeon. For his medical services as a chief surgeon of the army hospital in Krasnoyarsk at the outbreak of World War II, he was awarded the medal "For valiant labour in the Great Patriotic War 1941–1945" (Antonopoulos, 2017, p. 367). In 1942, he was elevated to the rank of Archbishop and in 1945, he was merited the right to wear the Diamond Cross by

Patriarch Alexy I (Andreev & Ostroushko, 2017). In 1946 he assumed the position of the Archbishop of Simferopol and Crimea (Fig. 3), while he was also elected to honorary membership of the Moscow Theological Academy since his publicized sermons were recognized as unique in ecclesiastic theology (Antonopoulos, 2017, p. 470).

Figure 3. Saint Luke, Archbishop of Simferopol and Crimea (Antonopoulos, 2017, p. 419).

Among his written heritage as theologian, consisting of 1250 sermons published in 12 volumes the memorable book entitled "The Spirit, the Soul and the Body", was characterized as a significant achievement in science, theology and philosophy (Baloyannis, 2015; Popivanov, 2018). Based on his extensive scientific and philosophical background, as well as his Orthodox Christian beliefs and values (Baloyannis, 2015), Archbishop Luke used all the available literature in physics, chemistry, psychology, psychiatry and theology in order to prove that man consists of a nonmaterial spirit and soul as well as a body (Popovsky, 1979). To this end, he believed that the spirit is the true essence of human, and that both the soul and body act as mediator between him and the world, interacting at the point of the act of human consciousness (Zaluzhna & Veremeichyk, 2020).

In 1955, he was completely blind and retired from his medical duties, but he continued to preach and lead the diocese. In 1959, he had to deal once again with an unprofessional behaviour of his academic colleagues due to his Christian beliefs. He declared: "Our great physiologist Pavlov, the academician Vladimir Petrovich Filatov, the priest-scientist and astronomer Nicolaus Copernicus, and Louis Pasteur, were able to combine scientific work with their deep faith to God" (Antonopoulos, 2017,

pp. 460–461). He died peacefully in 1961, and he was buried with honor in the All Saints cemetery of Simferopol. In 1995, Archbishop Luke was canonized as locally venerated saint of the Crimean diocese, while in 2000, he was glorified as Saint in the Assembly of new martyrs and Confessors of Russia by the Russian Orthodox Church (Andreev & Ostroushko, 2017; Antonopoulos, 2017, pp. 503–504; Popivanov, 2018; Begiev, Begiev, & Yakovleva, 2020).

Conclusions.

Voyno-Yasenetsky was a pioneer surgeon and academic professor. He worked extensively on the field of general surgery, pyogenic infections and regional anesthesia and published numerous research articles and books. He pioneered many innovative procedures within the spectrum of several surgical specialties. He treated the wounded patients and taught the young doctors. Among his research works, the monograph entitled "Essays on the surgery of pyogenic infections" served as a reference tool and guidebook for the next generations of physicians. He received professional honor for his contribution, after he was awarded the State Stalin Prize of first degree. As a theologian, philosopher, and bishop, he dedicated his life not only to the medical science and suffering people but to the Orthodox Church as well. After living a simple, genuine, and pure life, he elevated to the rank of Archbishop and he was glorified as Saint Luke by the Russian Orthodox Church. Following the adoption of new scientific innovations in the field of Medicine Saint Luke (Valentin Felixovich Voyno-Yasenetsky) received an honorable place in the history of Medical Sciences.

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Спадщина Святого Луки (Валентина Феліксовича Войно-Ясенецького) в медичній науці

Анотація. *Святий Лука, архієпископ Сімферопольський і Кримський (1877–1961), Валентин Феліксович Войно-Ясенецький, народився у Керчі у Криму. Він був видатним лікарем, і працював академічним професором топографічної анатомії та оперативної хірургії в медичній школі Ташкентського університету. Він багато працював у галузі хірургії, регіонарної анестезії, гнійних інфекцій, офтальмології, нейрохірургії, онкології, ортопедії, оториноларингології, гінекології, урології та стоматології, часто за складних*

обставин. Він робив найрізноманітніші операції, від незначних амбулаторних процедур до надзвичайно складних, з подальшим довготривалим стаціонарним лікуванням. Він опублікував численні наукові статті та книги. Його найвідоміша монографія під назвою "Нариси хірургії гнійних інфекцій" ("Нариси гнійної хірургії") зосереджена на широкому полі хірургії з особливостями хірургії гнійних інфекцій та послужила довідковим інструментом та путівником для наступних поколінь лікарів. Сталінська премія була найвищою професійною відзнакою, яку Валентин Феліксович Войно-Ясенецький отримав від радянської держави як визнання його внеску в науку. Войно-Ясенецький був талановитим лікарем, який мав великий вплив як на пацієнтів, так і на колег, завдяки своїм фундаментальним етичним принципам та цінностям, заснованим на християнських віруваннях. Його життя та наукова діяльність були прикладом практичної єдності наукової істини та релігійної віри. Він був призначений дяком і священником, а пізніше висвячений до чинів єпископа та архієпископа. Він був заарештований і згодом засланий за свої релігійні вірування та прославлення православної церкви. В Росії в 2000 році відбулося загальноцерковне прославляння святого Луки, як визнання святості Бога, що виявилося в його житті. Святий Лука отримав почесне місце в історії медицини та Східної Православної Церкви. Це дослідження має на меті висвітлити ключові елементи його життя та його науковий внесок.

Ключові слова: *Святий Лука; Войно-Ясенецький; ліки; наука; Сімферополь*

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Аннотация. *Святой Лука, архиепископ Симферопольский и Крымский (1877-1961), родился Валентин Феликсович Войно-Ясенецкий в Керчи, Крым. Он был выдающимся врачом и работал академическим профессором топографической анатомии и оперативной хирургии в медицинской школе Ташкентского университета. Он много работал в области хирургии, регионарной анестезии, гнойных инфекций, офтальмологии, нейрохирургии, онкологии, ортопедии, оториноларингологии, гинекологии, урологии и стоматологии, часто в сложных обстоятельствах. Он делал самые разные операции, от незначительных амбулаторных процедур до чрезвычайно сложных, с последующим длительным стационарным лечением. Он опубликовал многочисленные научные статьи и книги. Его самая известная монография под*

названием "Очерки хирургии гнойных инфекций" ("Очерки гнойной хирургии") сосредоточена на широком поле хирургии с особенностями хирургии гнойных инфекций и послужила справочным инструментом и путеводителем для последующих поколений врачей. Сталинская премия была самой высокой профессиональной наградой, которую Валентин Феликсович Войно-Ясенецкий получил от советского государства как признание его вклада в науку. Войно-Ясенецкий был талантливым врачом, который имел большое влияние как на пациентов, так и на коллег, благодаря своим фундаментальным этическим принципам и ценностям, основанным на христианских верованиях. Его жизнь и научная деятельность были примером практического единства научной истины и религиозной веры. Он был назначен дьяком и священником, а позже рукоположен к чинам епископа и архиепископа. Он был арестован и впоследствии сослан за свои религиозные верования и прославления православной церкви. В России в 2000 году произошло общецерковное прославление святого Луки, как признание святости Бога, что оказалась в его жизни. Святой Лука получил почетное место в истории медицины и Восточной Православной Церкви. Это исследование имеет целью осветить ключевые элементы его жизни и его научный вклад.

Ключевые слова: *Святой Лука; Войно-Ясенецкий; лекарства; наука Симферополь*

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I. H. Verkhratskyi (1846–1919): at the origins of Ukrainian natural science

Abstract*. Among the scientists of European greatness, who at the turn of the XIX and XX centuries showed interest to the folklore of Galicia (Halychyna) and Galician Ukrainians, contributed to their national and cultural revival, one of the leading places is occupied by the outstanding Ukrainian scientist Ivan Verkhratskyi (in some other sources – Verkhratsky). He was both naturalist and philologist, as well as folklorist*

and ethnographer, organizer of scientific work, publisher and popularizer of Ukrainian literature, translator, publicist and famous public figure. I. H. Verkhratskyi was also an outstanding researcher of plants and animals of Eastern Galicia, a connoisseur of insects, especially butterflies, the author of the first school textbooks on natural science written in Ukrainian. The scientist also wrote poetry and translated from foreign languages. The article covers the life and scientific and pedagogical activities of I. H. Verkhratskyi – one of the founders of Ukrainian natural science, who made a significant contribution to the development of Ukrainian natural terminology and nomenclature, the author of the first textbooks on botany, zoology, mineralogy. The authors believe that I. H. Verkhratskyi can be considered one of the founders of Ukrainian scientific terminology in Natural Science, and today his works in this area remain relevant. These works are also valuable from the historical and cognitive points of view as one of the sources for studying the process of formation of the Ukrainian literary language and scientific and natural terminology. I. H. Verkhratskyi devoted himself to the establishment of the Ukrainian literary language, its scientific and journalistic backgrounds, and made a significant contribution to lexicography, dialectology, and schooling. Based on the scientific publications and memoirs of his colleagues and students, the authors have recreated the main stages of his biography and considered his professional career. His activity in the field of formation of natural science terminology have been considered in detail. Dialectological materials of the scientist and researcher I. H. Verkhratskyi are still actively used to study the Galician and Transcarpathian dialects. His achievements as a scientist, teacher and popularizer of science has been summarized.

Keywords: *natural terminology; zoology; botany; Lviv University; Taras Shevchenko Scientific Society*

Introduction.

The history of science can be covered from different standpoints and be equally true. One of the ways to reconstruct the history of science is to study the biographies of scientists who were at the origins of various research areas. In Ukrainian natural science, there are quite a few bright figures, which are notable not only for outstanding scientific achievements but also characterized by high moral and human qualities.

An example of a man who was true to himself to the end and did not sell the scientific principles can be a prominent Ukrainian researcher of nature Ivan Hryhorovych Verkhratskyi. His merits before Ukrainian natural science are enormous: he introduced the concepts of “globe”, “equator”, “meridian”, for the first time he studied the processes of creating Ukrainian natural science terminology and nomenclature. He belongs to the constellation of prominent Ukrainian scientists of the last quarter of the XIX – early XX centuries. His name belongs to the golden fund of Lviv University. Thanks to his scientific and educational activities, the foundations of Ukrainian natural science were laid (Zhelezniak, 2005; Zagorodniuk, Parkhomenko, & Kharchuk, 2017; Kravets & Holiney, 2016). The memory about this outstanding

natural scientist deserves to be preserved today as a guarantee of further development of a society that knows, appreciates and continues to develop the achievements of its predecessors. In addition, the study of the heritage of outstanding scientists of the past has, in addition to purely historical, sometimes also of great practical importance. Many areas that started in the XIX century receive further development today. Some ideas started in the XIX century are still working and are implemented today in various fields of science and technology (Holovatskyi, 2003).

Literature review.

The first attempts at an in-depth assessment of the life and work of I. H. Verkhratskyi can be considered obituaries written immediately after his death by prominent scientists. In the process of revived interest in life and scientific activity of I. H. Verkhratskyi, many unknown materials from his legacy were discovered.

However, there is still no scientific work that would consider the contribution of I. H. Verkhratskyi in the Ukrainian natural sciences in full. Writing such a work is complicated by the fact that there is still no complete bibliography of printed works of the scientist. To date, bibliographies present only his most basic works or works devoted to one topic, which significantly narrows the possibilities to assess his activities. Until 1940, such research was not conducted at all, so historians had to rely on encyclopedic publications (Kubiyovych, 1993). In soviet times, the works of I. H. Verkhratskyi were considered by several scientists (Shumanska, 2005; Khomliak & Shenderovskyi, 2003; Shevchuk, 2008; Bezdrobnyi, Kozurskyi, & Shenderovskyi, 2012; Hamaliia, 2013; Gamaliia, Ruda, & Zabuga, 2021).

The purpose of this article is to outline the life and work of Professor Verkhratskyi as an outstanding naturalist, the founder of several fields in Ukrainian natural science.

Results and discussion.

Ivan Verkhratskyi was born on April 26, 1846 in the village of Bilche Zolote in the Ternopil region. Here is how Vasyl Shenderovskyi writes about this region: “Ternopil. Podillia land. This region is rightly called “golden”. Nature has endowed this part of Ukraine with fertile soils, necessary water resources, honey supplying meadows and, of course, talented people. It is this land that has given humanity world-class scientists – physicists Ivan Puliui, Oleksandr Smakula and Zenon Khraplyvyi, biochemist Ivan Horbachevskyi, outstanding singer Solomiia Krushelnytska, writer Bohdan Lepkyi, Cardinal Yosyp Slipyi, composer Vasyl Barvinskyi … And among the bright stars of this galaxy the star of Ivan Verkhratskyi is shining too” (Shenderovskyi, 2006, p. 42).

The family roots of I. H. Verkhratskyi were lost in time. Today, we know only a few immediate generations, whose lives are connected with the Ternopil region. Residents of the village of Kryvenke, now part of the Husiatyn administrative area, still remember Ivan’s great-grandfather, Pavel Verkhratskyi, who built a church in the village at his own expense. Later, his son Hryhorii moved to the village of Bilche

Zolote (now Borshchiv administrative area, Ternopil region), where he began working as a priest. In fact, on April 26, 1846, a son, Ivan, was born, who was the youngest of four children.

Vasyl Shenderovskyi writes in this regard: "The families of priests at that time made up the real Ukrainian intelligentsia. Their families were not much different from ordinary peasant families, but for a long time, the families of priests were the light that prevented the idea of national self-expression in the darkness of statelessness, cultural oppression and denationalization. Unfortunately, we still know little about them, only from individual publications. But let us mention at least the Kulchytskyis dynasty – a model of patriotic educational activities for several centuries. The Verkhratskyis also belonged to such conscious clergymen" (Shenderovskyi, 2006, 42).

When Ivan was two years old, his father died. The family moved to Lviv. All worries about the education of children fall on the shoulders of the mother. She came from a Croatian-German family, but it is to her that children owe their upbringing in the best Ukrainian educational traditions. At first, Ivan studied in elementary school, later in Lviv academic gymnasium. Yet in the gymnasium, the young man is interested in natural science: gathers collections of insects, an herbarium. After leaving the gymnasium, he entered the Faculty of Philosophy at Lviv University, where he studies natural sciences, as well as linguistics and ethnography. In 1864 he published his first scientific work "The beginnings to establish the nomenclature and terminology of natural history, of folk one" (Verkhratskyi, 1864). Later, between 1869 and 1879, five more issues of the dictionary were published one after the other.

These books were the first step in creating a Ukrainian scientific language in the field of natural science. They contain the results of the long and systematic work of the scientist, who collected several thousand folk names of plants, animals, birds, insects, created a scientific nomenclature of invertebrates. O. Rozhniatovska notes in this regard: "In addition, folk biological terminology is given, i.e. expressions that characterize the external and internal structure and functions of plants and animals. There is also information about the origin of the names, numerous beliefs, superstitions about natural objects, their properties and methods of use. The researcher revealed the enormous richness of our language. He discovered a wide range of folk names that very accurately reflect the properties of plants and animals. "The beginnings to establish the nomenclature…" were praised by Slavists as a remarkable achievement in the study of the Ukrainian language and culture. This work is still of scientific interest to historians and dialectologists of the Ukrainian language" (Rozhniatovska, 2015).

After graduating from Lviv University, I. H. Verkhratskyi failed to receive a scholarship to continue his studies abroad. He had to work in various schools and gymnasiums in Galicia: first in Drohobych (1868), and later in Stanislaviv, Riashev and Lviv (in the Academic Ukrainian Gymnasium). He mainly taught Ukrainian language and natural science. During this time, I. H. Verkhratskyi became famous as a good teacher, scientist and public figure. The positions of the Ukrainian populists were closest to him in spirit. The Ukrainian populists' movement arose under the influence

of the works of Shevchenko, Shashkevych, Kulish, Kostomarov, Fedkovych. In general, the ideas of national liberation were close to I. H. Verkhratskyi and he did not deviate from them during his life. It is important to note that in the Drohobych gymnasium the young I. Verkhratskyi taught Ivan Franko, taught him the Ukrainian language and mathematics. It is known that in a letter to M. Drahomanov Ivan Franko wrote: "I was influenced by the development of literary taste by two teachers: Ivan Verkhratskyi and Julius Turchynskyi" (Franko, 1986, p. 242).

To obtain a qualification in zoology, Ivan Verkhratskyi entered the Jagiellonian University in Krakow, where he studied under the guidance of the famous Galician naturalist, Professor of Zoology M. Sila-Nowicki. After graduating in 1874, already as a qualified zoologist, I. H. Verkhratskyi worked as a teacher at the gymnasium in Riashev (now Rzeszow, Poland). From 1879 he taught in Stanislaviv, and from 1892 until his retirement in 1908 he taught at the Lviv Academic Gymnasium named after Franz Joseph, the oldest Ukrainian gymnasium in Galicia.

Pedagogical activity does not overshadow the scientific activity of a young scientist. At first, I. Verkhratskyi's attempts in the field of etymology and to classify Western Ukrainian dialects were of an amateurish nature. However, his descriptions of the dialects of Galicia, Bukovina, and Transcarpathia, especially the data he collected on their vocabulary and emphasis, had a positive effect because of the great factual material. And all this despite the lack of scientific methods at the time. In his younger years, he published poetry, translated and tried his hand at literary work. He publishes several books in Ukrainian with the sole purpose of contributing to the development of literature in the Ukrainian language.

During 50 years of creative work, I. H. Verkhratskyi had published almost 500 scientific papers, popular science articles, reviews and notations. Such his folklore collections as "Utmost needings to the South Ruthenian Dictionary" (1877) (Verkhratskyi, 1877), "A list of the most important expressions in Ruthenian botanical terminology and nomenclature with a review of school science in the upper classes of the gymnasium" (both – 1892), (1892) (Verkhratskyi, 1892), "New needings of nomenclature and terminology of natural history, folklore, collected among the people" (1908) (Verkhratskyi, 1908) became the golden fund of Ukrainian folklore. No wonder the Chronicle of the Taras Shevchenko Scientific Society published wonderful words about him: "Anyone who had been working for 50 years, like Ivan Verkhratskyi, in the development of native science and literature, who had been giving for the development that he could and knew, who had been working when he could not hope for his work not only material benefits but even recognition, he deserved a grateful memory of his descendants..." (Melnyk, 1922).

Besides, I. Verkhratskyi is the author of several outstanding theoretical works on floristics, which have not lost their significance till now. I. Verkhratskyi's voice was also authoritative in linguistic, historical and natural science issues (Udvari & Viga, 2005; Ciwkacz, 2009; Fałowski & Hojsak, 2020; Czetyrba-Piszczako, 2020; Bury, 2020).

He used every summer vacation for scientific trips. At various times he visited Vienna, Budapest, Trieste, Zurich, Paris, Venice, where he worked in museums, botanical gardens, visited scientific institutions. In 1878 he carried out an ethnographic expedition to the north and south of Ukraine, conducting interesting linguistic research in Kyiv, Zhytomyr, Odesa, and Kherson regions. Throughout his life, Verkhratskyi worked hard to improve the state of the Ukrainian language in science and education. Although in the second half of the nineteenth century our literary language, thanks to the classics of fine writing, had already been formed in general, but the written word of scientists, government officials, and journalists was extremely artificial and awkward. A large part of the Galician intelligentsia was under the influence of Muscoviteism and focused on the so-called "higher style" with a large admixture of Church Slavonic. The unnaturalness of such a phenomenon was acutely felt by Verkhratskyi, who put it this way: "... the word of literature, whether in fiction or science, must grow from the basis of folklore ... In scientific works, language must be very diligent; the deeper the terminology has its roots in the living conversation of the people, the stronger it is and the more useful the conditions of life and duration it has" (Verkhratskyi, 1902, p. 83). He also spoke out against excessive language borrowings: "It is not at all good for us to borrow, we do not need to go all the way to Muscoviteism; we have enough of our good names, although for the time it is being scattered, uncollected and disordered ... We only exist when we develop on our own, natural, written foundations" (Verkhratskyi, 1902, p. 94–95). However, the creation of a scientific language required a lot of philological and ethnographic work. It was necessary to collect among the people a large number of special terms, as well as to identify among them the most used and successful. This is what Ivan Verkhratskyi directed his forces to.

Verkhratskyi revealed the enormous richness of our language. He discovered a wide range of folk names that very accurately reflect the properties of plants and animals. These are, for example, the names of plants – "samosiia" (self-seeder), "zymozelen" (evergreens), "khreschate zillia" (cruciferous potion); birds – "svystulia" (whistler), "bilohrudnyk" (white-breasted), "tsvirkar" (crickets), "dovbalo" (woodpeckers); insects – "serpokryl" (crescent), "dzyhotka" (twig), "odnodnevytsia" (diurnal). The same natural object usually has several synonymous names, which sometimes occur even in the same area. Verkhratskyi wrote: "The more names, the richer the language; therefore, having synonyms, we do not need to feel sorry at all, because, as we have been told it is in our favor, in that respect we are many times richer than other Slavic brothers ..." (Verkhratskyi, 1899, p. 6).

The scientist had been persistently collecting folk names every year for many decades. In 1908, in the "Collection of Mathematical-Natural-Medical Section of NTSh" (NTSh means Taras Shevchenko Scientific Society) he published a voluminous work entitled "New needings of the nomenclature and terminology of natural history, folklore …", which contained a very rich natural and ethnographic material (Pantso & Parasyn, 1996). In total, this work records about two thousand local names of plants

and about the same number of animals, as well as a huge amount of folk information about them. This is the largest work of its kind carried out by Ukrainian scientists. The material is collected in about 150 settlements, and it is specified where each name comes from. Verkhratskyi conducted these ethnographic researches mainly on those Ukrainian lands that were part of the Austro-Hungarian Empire – Galicia, Bukovina, Transcarpathia, but this also included the results of travel to Polissia and the Black Sea regions. Data from other scientists were also given.

Verkhratskyi's ethnobotanical and ethno-zoological heritage is invaluable for linguists, in particular for dialectologists. This legacy of his, along with numerous works devoted to the study of various Ukrainian dialects, deserves further study. However, the other side of the scientist's activity gained special importance – the formation of the Ukrainian scientific language on a national basis – terminology and nomenclature (systems of names of plants, animals, minerals). The terminology on natural sciences created by Verkhratskyi is given in a number of his textbooks, as well as in some special works, such as the terminological manual on botany for gymnasiums (Verkhratskyi, 1905). In 1909, the scientist published an explanatory dictionary of mineralogical terminology (Verkhratskyi, 1909). Thus, Verkhratskyi became the creator of scientific language in many areas of science.

It should be noted that the terminology proposed by him was later not fully accepted. It had been further improved. This is understandable, because the matter of forming a scientific language is beyond the power of one person. Not all terms were successful, in particular those that were not based on the folklore, but were created artificially. Unfortunately, I. H. Verkhratskyi, a profound connoisseur of various dialects, did not fully accept the literary language that was formed in both Eastern and Western Ukraine at the turn of the nineteenth and twentieth centuries.

Despite this, the achievements of I. H. Verkhratskyi are invaluable. He is considered the best specialist in terminological issues in all the natural sciences. Many naturalists and teachers from different parts of Ukraine turned to him for oral or written advice. Modern Ukrainian scientific botanical and zoological terminology and nomenclature are based mainly on the works of I. H. Verkhratskyi. Of particular value are materials relating to invertebrates, including insects, because now their folk names are almost forgotten. In the 1920s, I. Verkhratskyi's terminological legacy was carefully studied by commissions that operated in each area of natural sciences at the Institute of the Ukrainian Scientific Language of the USSR Academy of Sciences.

The end of the XIX – beginning of the XX century became the period of laying the preconditions for the formation of the Ukrainian scientific language. At that time, there was no diverse and systematic scientific terminology, and, consequently, the Ukrainian scientific language. However, at the turn of the century, the activities of the Taras Shevchenko Scientific Society in Lviv, the oldest Ukrainian scientific association, were established and developed, in the depths of which scientific criteria for term formation on a national basis began to form. As O. Romaniv rightly noted, “Scientific Society named after Shevchenko (NTSh) is a unique collective

phenomenon of Ukrainian spirituality, an important factor in the formation of the Ukrainian nation in its long historical campaign to gain an equal place among civilized peoples of Europe and the world" (Romaniv, 1992, p. 3). Its predecessor was the Shevchenko Literary Society, founded in Lviv in late 1873. The idea of creating a voluntary association for the development of the Ukrainian word in Galicia was born in the circles of the then intelligentsia as a reaction to the legislative acts that hindered this development. More or less free opportunities for legal publishing and other educational activities of democratic circles of the intelligentsia lasted only for a rather limited period: from the abolition of serfdom in 1861 to the release of a circular of Interior Minister Valuiev in 1863. During this time, not so little was done: copies of "Fundamentals" were published in the printing house of P. Kulish. M. Kostomarov published the first public Ukrainian textbook of the writer and public figure O. Konyskyi (1836–1900) "Arithmetic or dash" (1863), in which, along with rational terminological innovations, there were also inorganic borrowings for the Ukrainian language: "skladaniie" (adding), "otnosheniie" (relation), "dilytel" (divider), "prymir" (example). "Zero" O. Konyskyi called "onyk" (O-shaped), the "reverse" – "navpakove" (oppositive, contrarious).

In 1863 a pamphlet by I. H. Verkhratskyi "Something about the world of God", where there appeared terms that have survived to this day: "globe", "equator", "meridian", and for the last two were given quite organic Ukrainian equivalents: "rivnodennyk (from the equal day)" and "pivdennyk (from the south)", created by analogy with the Polish "rownik" and "poludnik" (Verkhratskyi, 1863).

In the preface to the issue "The beginnings to establish the nomenclature and terminology of natural history. Part 2" I. Verkhratskyi explained that he collected Ukrainian names in Galicia, questioning peasants, archers, poultry farmers and fishermen, and took some from books published in Ukraine. This work is not easy, especially for botanical names, which are far more numerous than zoological ones. Therefore, the author invited everyone to participate in the work, giving them appropriate recommendations for collecting plant names. The plant should be dried and a card attached to it, where it should be written its popular name, place of its growth, beliefs and superstitions associated with it. There can be several names, depending on the place of collection of the plant, and this should not interfere: "... in every language, namely, in the living one there is a diversity in that view, they are synonyms. The most appropriate name is chosen for science, and others, as trivial ones, are enclosed in parentheses ... and the more names, the richer the language; therefore, having synonyms, we do not need to grovel before anybody, because, as it is said, it is in our favor, and in that respect, we are often richer than other Slavic brothers: Muscovites, Liakhs, Czechs, Serbs and others" (Verkhratskyi, 1869, p. 4). Here is one of the typical examples of botanical nomenclature, taken from the second issue of "Beginnings ...": "Allium cepa, Gemeine Zweibel, Zipolle, Onion. The first year they plant vysadky (large onions), and for a year they sow siianka (seeds from large onions), from which there grow small onions. Those small onions are taken and hung in bags at

both ends sewn over the stove (that's why it is called "dymky" (that means smokes)) for "wakening the onions up" and are planted for the third year to have large onions. Not well "wakened up" onions let long bellies or columns, but has small onions. If it turns out as it should, the green tops will be small in it, but the onion is big" (Verkhratskyi, 1869, p. 28).

If in the first two issues the researcher contained only terminological names written from the people "exactly as he heard and recorded, without allowing any changes", then later, not finding the appropriate term in the vernacular, he allowed himself to create it artificially. In general, the third issue, according to its author, contains much more Ukrainian names than the first two. He explains this by the fact that he received valuable terms from his correspondents from Ukraine, and also chose many of the two books: "On wild medicinal plants of Poltava province" by F. M. Avhustynovych and "Travel with a zoological purpose to the northern shore of the Black Sea and in the Crimea" by K. Kessler. There are also many synonyms of plant names: "Triticum vulgare L., gem. Weizen, Wheat. Vusachka (from mustache) – mustache wheat (awned wheat), Bartweizen; Stryzhachka (from shear) – bare wheat (awnless wheat), Unbergranntner Weizen. Perevidka-vusata wheat (once sown in winter, once in spring, alternately, in turn); Maryianka-wheat fine-grained, red, spring, usually without awns; Holka – naked wheat, sheared" (Kessler, 1860, pp. 16–17).

In the 6th issue, in addition to the nomenclature, some folk dialects are given, scientific terms formed by the author on foreign samples due to the lack of appropriate Ukrainian are given: Straight root, Pfahlwurzel, radix perpendicularis; Woody root, Holzige Wurzel, radix lignosa; Fleshy root, fleischige Wurzel, radix racemosa, etc. The issues of "Beginnings…" are ended by I. Verkhratskyi with this tirade of the author: "Although not all the names given here are suitable for scientific terminology, it is worth knowing how our people call the rich natural fruits of their native land. Knowing this we will take one step further in getting to know our people – and knowing our people is a great and honest duty of every enlightened patriot. Only by knowing our native, our specific good we will be able to love and appreciate it" (Verkhratskyi, 1879, p. 6).

I. Verkhratskyi's work was positively evaluated not only by his contemporaries but also by scientists of the XX century, who studied the ways of development of Ukrainian scientific terminology. Thus, L. Symonenko notes: "Attempts to systematize the existing terminology and create a new one, proposed by I. H. Verkhratskyi in the "Beginnings to establish the nomenclature and terminology of natural history" are considered fundamental in the systematization of Ukrainian terminology… Terminological works of I. H. Verkhratskyi even now are of considerable interest primarily to the wealth of dialectal natural nomenclature collected in them" (Barna, & Barna, 2013, p. 31). And M. L. Khudash believes that these works are valuable from the historical and cognitive point of view as one of the sources for studying the process of formation of the Ukrainian literary language and scientific and natural terminology (Khudash, 1971).

Over time, the situation for the deployment of legal educational activities in Ukraine became more complicated, and then Oleksandr Konyskyi took the initiative to organize a hotbed in order to "help the development of Ruthenian (Ukrainian) literature". This was done at a time when, as M. Hrushevskyi wrote, "the possibility of Ukrainian culture was endangered when even its defenders, for the most part, did not dare to go beyond the postulates of fiction on folk, ethnographic topics and basic popular literature for the peasantry".

The statute of the society was drawn up on behalf of members of the Ukrainian Community D. Pylchykov and M. Drahomanov. On December 11, 1873, it was approved by the Galician governorship, and on June 4, 1874, the first general meeting was held. The Shevchenko Society (the first society in Ukraine named after the great Kobzar) had a literary character, but in this guise, it managed to do a lot of useful things, especially in the field of publishing after the Ems decree of 1876 banning the printing of Ukrainian books in the Russian state or import them from abroad. Thus, in 1880 the Society published a book by its member, Professor of Ukrainian Philology at Lviv University Omelian Ohonovskyi, who defended the independence of the Ukrainian language, its distinctive character from Polish and Russian. In 1889 the publication of the "History of Ruthenian Literature" by the same O. Ohonovskyi began, where the idea of the distinctiveness of the Ukrainian people and the originality of its writing was shown on the base of a large amount of gathered material. In 1885, the Society took over the publishing house of the journal for Ukrainian families "Zoria", which soon became an all-Ukrainian literary and scientific journal, which published works by Ukrainian writers, including Lesia Ukrainka, Mykhailo Kotsiubynskyi and others. It was on the columns of "Zoria" in December 1894 that the philological section of the NTSh published an appeal "To compatriots", where it called for the collection of folk terminology because when compiling dictionaries, it is often difficult to find a suitable Ukrainian term.

And even against the background of all these important works, there is a great scientific legacy left by I. H. Verkhratskyi, who began collecting folk names at the age of seventeen, having published his materials for the zoological dictionary in the Lviv weekly "Vechernytsi". Later the already known "Beginnings...", his "Utmost needings to the South Ruthenian Dictionary" were published, as well as the fundamental work "New Needings of Nomenclature and Natural Terminology...", where more than 2000 local names of animals and as many folk names of plants were given, places of their growth, as well as information on their application, were described. The material was collected in almost 150 settlements, mainly in those lands that were part of the Austro-Hungarian Empire – in Galicia, Transcarpathia, Bukovina, this included the results of a trip to Polissia and the Black Sea regions. In 1909 the scientist published an explanatory dictionary in mineralogical terminology. Using his rich terminological material, he created a series of textbooks that supplanted the German and Polish languages (being common in Galicia at the time) and which Galician students studied until 1917.

Of course, I. Verkhratskyi's terminological elaborations were not absolutely completed. As M. Melnyk wrote, against the attempt to create the permanent nomenclature of Ukrainian plants published by I. Verkhratskyi, "... accusations were made more than once as if it were artificial, incomprehensible and difficult to study. I agree that there are a lot of artificial names in it ... But apart from that, the study of all purely folk terms is very important, because it shows the way our people create names and how we should act when creating new terms in science. This rule was followed by Verkhratskyi and therefore his scientific nomenclature of plants is the closest to the folk" (Kobiv, 1992, p. 502). Mykola Melnyk, taking the scientific names of plants introduced by I. Verkhratskyi, taking into account the work of other researchers: M. Annenkov, A. Rohovych, V. Shukhevych, O. Yanata, etc., carried out extensive ethnographic work, supplemented the list of phytonyms and published "Ukrainian nomenclature of higher plants", which contains about five thousand identified names of plants, indicating the place of their growth, opportunities for use, etc. He hoped that his collection would be useful not only for scientists, pupils and students but also for practitioners: farmers will find in it a description of almost all household, urban, meadow and forest plants with the names that are known in science and trade". (Kobiv, 1992, p. 5). Based on a careful analysis of the popular names of plants and their distribution, he developed a complete system of scientific binary names of more than two thousand of the most common plants. He significantly supplemented the work of I. H. Verkhratskyi, because the nomenclature created by the latter was quite fragmentary and concerned only the plants mentioned in the curriculum. M. Melnyk's collection found its reader: its Ukrainian nomenclature was considered normative on the territory of Western Ukraine until 1939.

Thus, in the Taras Shevchenko Scientific Society, the work on the creation of Ukrainian scientific terminology and nomenclature had acquired a real scale and depth at the same time. In various fields of science, it was developed by scientists: philologists, historians, naturalists. It is quite natural that discussions about the methodology of terminological developments sometimes broke out between them. Thus, in 1903 V. Levytskyi wrote an article in which he proposed not to take international terms as the basis of chemical terminology, but to create their own, corresponding to the spirit of the vernacular. I. Horbachevskyi opposed this, believing that terminology should have an international basis, as folk terms are too specific and will make it difficult for foreign readers to read professional literature: "I think", he said, "that our terminology must, above all, be as close as possible to international terminology, and that ... the use of folk, completely original terminology, or terminology reworked from a close Slavic language, is unprofitable and unnecessary". The discussion was quite heated and lasted for a long time, at least until the 1920s. Most experts shared Horbachevskyi's opinion, while some, in particular I. Verkhratskyi and M. Melnyk sought consensus between the two positions. They believed that Latin as a dead and laconic language is very suitable for the creation of artificial words and therefore is common in the natural science nomenclature. At the same time, popular

names do not obey the rules of binary nomenclature common in biology, because living language calls each subject in one word, albeit very accurate, and does not pay attention to its similarity to others. So biologists had to compromise, and in their dictionaries cited both Latin and German plant names, as well as Ukrainian-language equivalents, and only in their absence created their own variants.

Conclusion.

I. H. Verkhratskyi was an extremely active and hard-working man and left behind a rich scientific, literary and journalistic heritage. Herbariums, collections of various insects belonging to the scientist, later became the basis of the Natural History Museum in Lviv. The researcher's dialectological materials are still actively used to study the Galician and Transcarpathian dialects. I. H. Verkhratskyi became the founder of Ukrainian scientific terminology in natural science, and today his work in this area remains relevant. The colossal factual material collected in them will be useful to many generations of researchers of the Ukrainian natural language, scientists.

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The authors declare no conflict of interest.

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І. Г. Верхратський (1846–1919): біля витоків українського природознавства

Анотація. *Серед вчених європейської величини, які на межі XIX і XX століть почали цікавитися фольклором Галичини і галицькими українцями, сприяли їх національному і культурному відродженню, одне з перших місць посідає видатний український вчений Іван Григорович Верхратський. Він був природознавцем і філологом, фольклористом і етнографом, організатором наукової праці, видавцем і популяризатором української літератури, перекладачем, публіцистом і відомим громадським діячем. І. Верхратський є також визначним дослідником рослин і тварин Східної Галичини, знавцем комах, особливо метеликів, автор перших шкільних підручників українською мовою з природничих наук. Вчений також писав вірші і робив переклади з іноземних мов. У статті висвітлюється життєвий шлях та науково-педагогічна діяльність І. Г. Верхратського – одного із засновників українського природознавства, який зробив вагомий внесок у розвиток української природничої термінології та номенклатури, автора перших підручників з ботаніки, зоології, мінералогії. Автори вважають, що І. Г. Верхратського можна вважати одним з основоположників української наукової термінології з природознавства, і в наш час його роботи в цій царині залишаються актуальними. Ці праці цінні й з історико-пізнавального боку як одне з джерел для дослідження процесу формування української літературної мови та науково-природничої термінології. І. Г. Верхратський віддано служив справі утвердження української літературної мови, її наукового та публіцистичного тилів, зробив вагомий внесок у лексикографію, діалектологію, шкільну справу. На основі наукових публікацій та спогадів його колег та учнів нами відтворено основні етапи його біографії та розглянуто його професійну кар'єру. Детально розглянуто його діяльність на ниві формування природничо-наукової термінології. Діалектологічні матеріали вченого і дослідника І. Г. Верхратського й досі активно використовують для вивчення галицьких і закарпатських діалектів. Підсумовано його досягнення як науковця, педагога та популяризатора науки.*

Ключові слова: *природнича термінологія; зоологія; ботаніка; Львівський університет; Наукове товариство імені Т. Шевченка*

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И. Г. Верхратский (1846-1919): у истоков украинского естествознания

Аннотация. *Среди ученых европейской величины, которые на рубеже XIX и XX веков начали интересоваться фольклором Галичины и галицкими украинцами, способствовали их национальному и культурному возрождению, одно из первых мест занимает выдающийся украинский ученый Иван Григорьевич Верхратский. Он был натуралистом и филологом, фольклористом и этнографом, организатором научной работы, издателем и популяризатором украинской литературы, переводчиком, публицистом и известным общественным деятелем. И. Г. Верхратский был также выдающимся исследователем растений и животных Восточной Галиции, знатоком насекомых, особенно бабочек и автором первых школьных учебников на украинском языке по естественным наукам. Ученый также писал стихи и делал переводы с иностранных языков. В статье освещается жизненный путь и научно-педагогическая деятельность И. Г. Верхратского – одного из основателей украинской естествознания, который внес весомый вклад в развитие украинской естественной терминологии и номенклатуры, автора первых учебников по ботанике, зоологии, минералогии. Авторы считают, что И. Г. Верхратского можно считать одним из основоположников украинской научной терминологии по естествознанию, и в наше время его работы в этой области остаются актуальными. Эти работы ценны и с историко-познавательной стороны, как один из источников для исследования процесса формирования украинского литературного языка и научно-естественной терминологии. И. Г. Верхратский преданно служил делу утверждения украинского литературного языка, его научного и публицистического тылов, внес весомый вклад в лексикографию, диалектологию, школьное дело. На основе научных публикаций и воспоминаний его коллег и учеников нами воспроизведены основные этапы его биографии и рассмотрена его профессиональная карьера. Подробно рассмотрены его деятельность на ниве формирования естественно-научной терминологии. Диалектологические материалы ученого и исследователя И. Г. Верхратского до сих пор активно используют для изучения*

галицких и закарпатских диалектов. Подитожены его достижения как ученого, педагога и популяризатора науки.

Ключевые слова: *терминология естествознания; зоология; ботаника; Львовский университет; Научное общество имени Т. Шевченко*

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Historicizing medical drones in Africa: a focus on Ghana

Abstract. *While the genesis of the drone technology is not clear, one thing is ideal: it emerged as a military apparatus and gained much attention during major wars, including the two world wars. Aside being used in combats and to deliver humanitarian services, drones have also been used extensively to kill both troops and civilians. Revolutionized in the 19th century, the drone technology was improved to be controlled as an unmanned aerial devices to mainly target troops. A new emerging field that has seen the application of the drone technology is the healthcare sector. Over the years, the health sector has increasingly relied on the device for timely transportation of essential articles across the globe. Since its introduction in health, scholars have attempted to address the impact of drones on healthcare across Africa and the world at large. Among other things, it has been reported by scholars that the device has the ability to overcome the menace of weather constraints, inadequate personnel and inaccessible roads within the healthcare sector. This notwithstanding, data on drones and drone application in Ghana and her healthcare sector in particular appears to be little within the drone literature. Also, few attempts have been made by scholars to*

highlight the use of drones in African countries. By using a narrative review approach, the current study attempts to address the gap above. Using this approach, a thorough literature search was performed to locate and assess scientific materials that focus on the application of drones in the military field and in the medical systems of Africa and Ghana in particular. With its sole responsibility to deliver items, stakeholders of health across several parts of the world have relied on drones to transport vital articles to health centers. Countries like Senegal, Madagascar, Rwanda and Malawi encouraged Ghana to consider the application of drones in her mainstream healthcare delivery. Findings from the study have revealed that Ghana's adoption of the drone policy has enhanced the timely delivery of products such as test samples, blood and Personal Protective Equipment to various health centres and rural areas in particular. Drones have contributed to the delivery of equity in healthcare delivery in Ghana. We conclude that with the drone policy, the continent has the potential to record additional successes concerning the over-widened gap in healthcare between rural and urban populations.

Keywords: *drones; medical drones; Africa; Ghana; Unmanned Aerial Vehicles (UAVs); Unmanned Aerial System (UAS)*

Introduction.

Drones, or Unmanned Aerial Vehicles (UAVs), are smaller aircrafts controlled by computers and pilots (Coeckelbergh, 2013; Scot and Scot, 2017). They are short-range technology that can fly twenty (20) minutes or more before batteries are replaced or charged (Lin, Karishma, Cherie, & Sachin, 2018). In contemporary times, drones have been applied to various sections of human endeavor. The major application of this technological device is its usage as a delivery mechanism for the transportation of items in timely manner (Scott & Scott, 2017). Also, areas such as photography, security, racing, architecture and consumer goods delivery have witnessed the application of innovative drones (Lin, Karishma, Cherie, & Sachin, 2018).

Recently, advancement in medicine and the application of technology to medicine have given rise to the use of medical drones to carry medical equipment to service the needs of people in emergency situations (Bamburry, 2015). Their ability to bypass road closures and fly over terrains with no risks made them ideal for such purposes (Balasingam, 2017).

Africa, and Ghana in particular, is consistently ranked at the bottom in the area of health and healthcare indicators (Mazibuko, 2019). Over the years, there has been a wide gap between rural and urban dwellers in Africa concerning healthcare delivery (Adindu, 2010). The hope to stem the growing wider disparity between rural and urban areas in the area of health has informed governments to implement relevant policies. Currently, one of such policies has been the introduction of medical drones. At their inception, it was anticipated that they will serve as mediums through which medical deliveries would be expedited to meet the growing needs of the population in

impassable areas. Evidence from earlier sources indicate that they have been used to transport equipment, pharmaceuticals and vaccines to -and fro- the rural areas.

Since its introduction, scholars have attempted to provide data on the impact of drones on healthcare across Africa and the world at large. For example, the studies of Balasingam (2017), Washington (2018), Ackerman & Strickland (2018) and Knoblauch et al. (2019) among many others have made important contributions to the discourse on drones. Indeed, drones have been introduced to support the healthcare systems of some countries in Africa south of the Sahara. These studies have reviewed the nature and state of the application of drones with emphasis on healthcare in Malawi and Rwanda (Balasingam, 2017; Lin, Karishma, Cherie, & Sachin, 2018), Madagascar and Senegal (Knoblauch et al., 2019; Nouvet et al., 2019) and some selected countries in East Africa (Ackerman & Strickland, 2018). The debates of these studies revolve around the strengths, opportunities and weaknesses of the technology in Africa's healthcare.

The above notwithstanding, data on Ghana appears to be limited within the drone literature. Thus, little is known about the extent to which the application and contribution of drones affect the health systems in Ghana. The nature of drone application in Ghana in relation to other African settings are not well understood. The current paper uses a narrative review approach to investigate the application of drones in African medical systems with particular reference to Ghana. Also, we have paid attention to how drones were applied to the fight against the COVID-19 pandemic in Ghana. Drawing on a narrative review approach, we seek to obtain a broader perspective on the theme in Africa. This would help us to establish clarity from the literature for our analysis and inferences based on existing evidence.

Method.

The current study uses a narrative review approach. The main rationale underpinning our reliance on the narrative review approach was basically to obtain a broader perspective on medical drones in Ghana and Africa in general. We were interested in establishing clarity in gleaning literature for our analysis and inferences based on existing evidence.

We have used both academic and non-academic literature sources to piece this manuscript. Concerning the academic, we conducted a systematic search in databases related to the development of drones in the world, Africa and Ghana in particular to locate information that were in line with the focus of the discourse. Data collected from government briefs, reports and opinion posts formed the non-academic sources of the discourse. The nonacademic sources were utilized in our hope to capture the latest information concerning drones and its application in Ghana.

Again, the scanty nature of published resources on the theme in Ghana partially influenced our idea of incorporating non-academic sources in the study. Both the academic and non-academic literature sources have been pieced together and grouped

thematically to reflect the object of the study. Significantly, the two different sources have been used to corroborate each other.

Literature search.

A thorough literature search was performed to locate and assess scientific materials concerning the application of drones in the medical systems in Africa. Databases such as google scholar, Science Direct, Wiley and Emerald Insight were used as search engines to locate scientific materials. The searches were done to identify materials that contained the following keywords or phrases: "drones", "history of drones", "drones in Africa", "application of drones", UAVs, and "drones in health and medicine". The titles and abstracts were screened for relevance and selection, to ascertain whether they were applicable to the discourse.

The criteria for selecting a material depended on the requirement that the material was published in English and possesses relevant data on any of the themes under review. In the course of selection, all materials that presented biased findings were ignored. All duplicate search results were exempted. Also, we did a thorough review of the references or the bibliography of the selected materials to further review and identify other studies worthy of contact. Concerning this, there was emphasis on materials that discuss the application of drones and medical drones in Africa and Ghana in particular.

Results.

Information from Table 1 below enumerates our search results from the various databases. Initially, our search in google scholar presented 11,200 journal articles. Out of this, 200 were finally contacted after a filter. Also, our initial search in the Science Direct database yielded 14,094 results, out of which 203 were contacted after filtering inapplicable materials. Similarly, a search in the Wiley database presented the researchers with 91, 963 sources. Only 94 of these were consulted after filtering. Concerning Emerald Insight, our initial search endowed us with 1002 journal articles; nine (9) were contacted. From the articles consulted, we further filtered after reading titles and abstracts. Through this process, irrelevant materials were forfeited for applicable ones.

Table 1. Search results from databases.

Database	Initial search results	Results after filter
Google Scholar	11,200	200
Science Direct	14,094	203
Wiley	91,963	54
Emerald Insight	1002	9

Discussions.

The drone.

Scholars are still contesting the conception of the drone across time and space. Existing literature argues that the term drone, was coined because of the similarity between the sound and loudness of old military unmanned target aircraft and that of a male bee (Rosser, Vignesh, Terwilliger, & Parker, 2018). Over the years, several terms have been coined to describe the activities of drones. These include Unmanned Aerial Vehicle, Unmanned Aerial Systems and unmanned aircraft. Concerning unmanned aerial vehicle (UAV), the term was first coined in the 1980s to describe autonomous or remotely controlled and multiuse aerial vehicles that are driven by aerodynamic forces and are capable of carrying a payload (Rosser, Vignesh, Terwilliger, & Parker, 2018). Among other things, scholars adopted UAVs to draw a distinction between same and other aerial systems including ballistic vehicles, gliders, balloons and cruise missiles. It has been argued that a more accepted term is Unmanned Aerial System (UAS) (Rosser, Vignesh, Terwilliger, & Parker, 2018).

The properties of drones differ depending on the kind of drone and its purpose. However, every drone has an air frame, propulsion system and navigation system. Rosser et al (2018) have argued that the most common configurations of drones include fixed-wing, rotary-wing, multi-rotor and hybrid designs. Most of the drones that exist today have remote sensing equipment, cameras, ground-penetrating radar, direct measurement sensors, communication equipment and cargoes (Rosser, Vignesh, Terwilliger, & Parker, 2018).

Drones exist in different sizes, shapes and sophistications. There is the hand-thrown Ravens and the forces' Global Hawk; which can reach altitudes of sixty thousand feet. Irrespective of the size, drones provide intelligence, surveillance and reconnaissance to war managers (Shaw, 2013, 2014). The MQ-1 Predator is the most widely recognized military drone in contemporary times. Its wingspan is 55feet with a length of 27 feet and can reach a speed of 135 miles per hour (mph). Many operators use remote technologies to control. It has been reported that more than 2,900 people have been killed in 442 strikes in Pakistan with drones playing a major role (Shaw, 2014; Rosser, Vignesh, Terwilliger, & Parker, 2018). An average drone flight involve dozens of human operators, analysts, observers and lawyers. In fact, the drone such as the MQ-1 Predator requires between 90 and 200 personnel (Elish, 2017). Today, drones appear much smaller than they were in the past.

History of drones.

The debate surrounding the history and emergence of drones in the world is complicated and unresolved. While some scholars associate the first application of drones to the 1800s (Balasingam, 2017; Attuquayefio, 2014), others like McDougal (2013) believes that drones first emerged during the First World War for military purposes. To those who support the former, one of the earliest recorded history in drone application happened in July 1849 when Austrians, after launching pilotless

balloons mounted with bombs, directed same against the city of Venice (Shaw, 2013). During the nationalist revolutions of 1848 in Europe, Austrians were struggling to hold onto their empire and had to deploy drones in their actions. Subsequently, they deployed about 200 war balloons against the Venetian Republic. While balloons had been used widely for reconnaissance missions, especially during the Napoleonic era, Austrian balloons assumed a new dimension: instead of human, they were loaded with 33 pounds of explosives (Packer & Reeves, 2013).

Table 2. Evolution and historical development of drones.[1]

Phase	Development	Time Frame
Phase I	The Target Drone	Early 20th Century
Phase II	The Flying Bomb Drone	Interwar Period
Phase III	The Surveillance Drone	Cold War
Phase IV	The Hunter-Killer Drone	Post-September 11, 2001
Phase V	The Police Drone	Post-September 11, 2001
Phase VI	Medical Drone	2015– till date

In contrast to the Austrian development, McDougal (2013) asserts that drone technology first emerged during World War I when the U. S. Navy hired Elmer Ambrose Sperry to develop a fleet of unmanned air torpedoes that could be directed by catapult to a specific target. However, it has been reported that during the United States Civil war, Confederate and Union forces had flown balloons for reconnaissance missions. Also, aerial surveillance later emerged in the 1898 Spanish-American War when the U.S military fitted a camera to a kite and became very extensive during World War I (Shaw, 2014).

The drone technology was revolutionized in the 19th century. Specifically, in 1896, Samuel Pierpont Langley, an American astronomer, developed a steam-powered aerodromes (Figure 1), unpiloted aircraft that were flown successfully along the Potomac River near Washington (Shaw, 2014). On May 6, 1986, Langley's discovery successfully flew for 3,300 feet (Kindy, 2021). As a result of his success, he obtained a substantial amount of $50,000 from the U.S government to build powered aircraft that can be controlled by pilots (Taylor, 1990). Considering the weight of a full-sized steam engine, Langley called on his assistant, Charles Manly, an engineer to build a gasoline engine (Wood, 1985; Pelsser, 2003). This resulted in a tandem-winged design with a cruciform tail that could be launched from the top of a houseboat using a new mechanism (Pelsser, 2003; Kindy, 2021).

During World War II, a remote controlled unmanned aerial devices were improved to target German troops. Furthermore, during the cold war, the technology of drone led to a new discovery called the rocket technology. Afterwards, many

[1] From Phase I to Phase V, drones were used as a military devices from the early 20th till date. However, in contemporary times, a new dimension has been added to drones technology, making it possible to be used within the healthcare sphere.

developed nations employed military drones on surveillance and reconnaissance missions (Shaw, 2014).

Militarily, drones have been used in combats and to deliver humanitarian services (Scott & Scott, 2017). Coeckelbergh (2013) reports that drones were used by countries like Afghanistan, Pakistan, Yemen and Somalia to battle both civilians and armed men. The September 11th event of 2001 prompted the CIA and Air Force to use drones for surveillance and missiles mission. This form of drones were called Predator Drones with Hellfire Missiles (McDougal, 2013). The Predator drone, first used in 1995 was only operated remotely in 2001 (Bowden, 2013; Elish, 2017).

Figure 1. Langley's Aerodrome (National Air and Space Museum Archives, Smithsonian Institution).

Figure 2. Langley's Aerodrome (National Air and Space Museum Archives, Smithsonian Institution).

Figure 3. SDI Surveillance drone (invented in England in 1962)[2] (Imperial War Museums).

Figure 4. Predator drone [3] (Bowden, 2013).

In 2002, six alleged Al-Qaeda operatives were killed by drone fire (Attuquayefio, 2014). An outstanding advantage of using drone for military purposes has been its proclivity to limit the number of personnel used to inflict more strategic pain on one's enemy (Coeckelbergh, 2013). They have been very useful in the areas of surveillance and for destruction of people and properties on the ground (Coeckelbergh, 2013).

[2] The SDI Surveillance drone was the first of a family of new drones that was acquired by the Royal Artillery in the 1960s to extend their observations over the battlefield and to locate targets for new long range weapons.
[3] The Predator drone has been used in times of war since the era of WWII. This was revolutionized in 1995.

In post September 11, scholars have termed drones as game changer of development and security across the globe and Africa in particular. Concerning the history of drones in Africa, the drone was first developed in the 1970s for surveillance purposes. According to Sandvik (2015), this innovation serves as a legacy of technological imperialism and colonial airpower. Within the apartheid era, South Africa witnessed the deployment and development of drone in their politics for about forty years. The first known type, the Champion, was developed by the South African Council for Scientific and Industrial Research in 1977 and handed over to the South African Air Force a year later (Sandvik, 2015).

The innovation and application of drones in Africa rose out of a growing concern and perception about Africa as an area in need of external drone intervention (Sandvik, 2015). This has caused major drone industries to identify and promote the use of drones in new areas including health and healthcare.

The essence of drone technology.

Since its inception, drone bombing became the most ultimate distancing technology in the military (Coeckelbergh, 2013). Since the reign of President Barrack Obama, the United States has relied on the use of drone's intervention in the growing conflicts across Africa and Sub-Saharan Africa in particular (Attuquayefio, 2014). As a pilotless aircrafts, the UAVs, popularly known as drones, give trackers easier and faster access to the often difficult terrain (Goodyer, 2013; Balasingam, 2017).

Aside developed countries, developing countries use drones to intervene in times of disasters, fire and during the outbreak of war (Scott & Scott, 2017). As a technology, the drone has been regarded as a disruptive force in the field of transportation (Scott & Scott, 2017). Following the military unrests that engulf sub-Saharan Africa, and Africa in general, the US and other stakeholders such as the United Nations (UN) have been deploying UAVs to convey military hardware such as missiles and cameras as well as network mediums for reconnaissance, surveillance and target engagement missions (Attuquayefio, 2014). In the *Hawaii International Conference on System Sciences* held in 2017, Scott and Scott argued that drones have also been used to fuel crimes including the delivery of contrabands to inmates. It also delivers firing weapons and encourages terrorism and hacking.

Aside the military, there is a growing body of literature that addresses the application of drones in several arenas of development and human endeavor across Africa and the world. The first non-military drone use occurred in an outbreak of a major disaster. Its ability to provide extreme human need in unfavorable geographical and transport networks made them ideal for such tasks. Among the major disasters that witnessed the application of drones include the 2010 Haiti Earthquake, the 2012 Hurricane in North-East U.S, Canada and the Caribbean, the 2015 Category 5 Cyclone in the Island of Vanuata and the 2015 Nepal Earthquake among others (Balasingam, 2017).

Over the years, the application of drones in various human endeavours have aided developments across the African region and the world at large as it reduces time, cost and improves delivery efficiency (Bamburry, 2015). Scientifically, drones have also been applied to the area of research and exploration for monitoring events such as fire outbreak and riots (Scott & Scott, 2017). They have been tried in data collection from remote areas (Bamburry, 2015). In sports and entertainment, drones have been used for live event coverages. In contemporary times, spraying of crops has been among the known roles played by drones in the world (Scott & Scott, 2017). In addition, drones have been given a centrality in the fight against poachers; they have been adopted to be used as an aerial surveillance mechanism to stem poaching in some parts of East Africa (Goodyer, 2013).

While drone usage has been projected by both Bamburry (2015) and Scott and Scott (2017) to be persistent in all states in the foreseeable future, it appears the future is closer than anticipated. Significantly, one notable application that has gained recognition among stakeholders is the adoption of drones in the area of medicine. Used for emergency services, the application of drones in medicine includes provision of disaster assessments when other means are restricted; delivering aid packages, medicines, blood, and vaccines to remote areas and for transporting disease test samples. In the era of COVID-19, drones proved very effective. It facilitated the delivery of medical supplies to mountainous and geographically challenging locations. It has been contended that, the congestion of cities and extreme weather conditions can be obstacles to emergency medical deliveries (Scott & Scott, 2017). The rest of the sections that follow address the application of drones in the African medical context.

Drones in African healthcare systems.

Africa has been noted as a continent with a myriad of systemic failures in several areas of development. In healthcare, the continent has been defined as the region with health system fragility (Adindu, 2010; Mazibuko, 2019). The incidence of health system fragility and the inadequacy of healthcare managerial skills have continually raised questions during the peak of major infections or epidemics in Africa (Adindu, 2010; Mazibuko, 2019). To lessen some of these burdens, several policies, including the use of drones in healthcare, have been adopted and implemented by African elites. Since its inception, medical drones have contributed immensely toward the delivery of healthcare in Africa and elsewhere.

Drones have been used for surveillance of disaster sites, areas with biological and chemical hazards and tracking the spread of diseases. Evidence suggests that in the Western countries, drones are used to gather information about the number of patients in need of care (George, 2017; Rosser, Vignesh, Terwilliger, & Parker, 2018). Serving as a means of improving efficiency, response teams of the National Health Service in England investigated the use of drones in assessing injuries related to chemical, biological and nuclear materials (Rosser, Vignesh, Terwilliger, & Parker, 2018).

Figure 5. Drone Transporting Medical Items in Switzerland[4] (Peck, 2019).

Also, the application of drones in medicine has improved the concept and practice of telemedicine. The technological literature provides evidence to suggest that drones have been extensively used for telemedicine. This includes the use of remote diagnosis treatment of patients by means of telecommunication technology (Rosser, Vignesh, Terwilliger, & Parker, 2018; Bhatt, Pourmand, & Sikka, 2018; Wulfovich, Rivas, & Matabuena, 2018). In several instances, the concept of tele-monitoring (the provision of remote guidance by an experienced surgeon to a less experienced colleague) using computers and telecommunication in healthcare has also been enhanced using medical drones (Rosser, Vignesh, Terwilliger, & Parker, 2018).

The successes elsewhere and within African countries such as Senegal, Madagascar, Rwanda and Malawi encouraged a country like Ghana to consider the application of drones in her mainstream health delivery (Washington, 2018). In Rwanda, her drone project commenced in 2016 (Lin, Karishma, Cherie, & Sachin, 2018). The purpose was to transport sachets of blood to peripheral health centers (Knoblauch et al., 2019). In this project, the implementation focused on regions where health facilities are isolated by Island geography (Knoblauch et al., 2019). Like elsewhere, the Rwandan drone technology extended services towards the transportation of lab samples, delivery of medical treatments for emergencies and delivery of medicines and medical supplies (Knoblauch et al., 2019). With evidence from advanced economies, drones have shown the proclivity of being used to ensure the extension of medical services to underserved areas. In the U.S, drones, since their inception, have continually supplied medication and other needed healthcare items to rural areas (Lin, Karishma, Cherie, & Sachin, 2018).

[4] The Swiss drone was manufactured by a California-based company known as Matternet. According to Peck (2019), the drone flew toward the opposite side of Lake Zurich to transport clinical laboratory samples between hospitals in urban areas.

In Rwanda, a California-based company known as Zipline is the primary inventor of the drone that delivers blood to remote areas in the East African country (Glauser, 2018). Zipline's goal is to be a primary distributor for most rural hospitals (Ackerman & Strickland, 2018). The Zip drones are able to make emergency deliveries at night through heavy rains, high winds, and darkness (Ackerman & Strickland, 2018). Drones have been used to transport blood products and medicines to hospitals with critical and/or severe cases as well as remote areas (Balasingam, 2017). Hospitals order blood and medicines via text messages and interactive platforms such as WhatsApps and receive them within 30minutes (Balasingam, 2017).

Aside the functions discussed above, Malawi's application has taken a different dimension. The literature reports on the application of drones concerning the fight against HIV/AIDs. It has been reported that the UN Children's Fund (UNICEF), continually use drones to deliver HIV test kits to the country. This reduces the time required to test infants within rural areas (Balasingam, 2017). In a similar manner, Google has partnered with UN Children's Fund (UNICEF) to use *Matternet* for the transportation of blood samples in Malawi. The various samples are transported from rural communities in Malawi and other African countries to large hospitals to test HIV/AIDs and other disease (Lin, Karishma, Cherie, & Sachin, 2018). Also, Washington (2018) adds that Malawi's drones are used to identify cholera hotspots in Lilongwe – the capital of Malawi. Again, Washington hints that, aside Malawi, countries like Ghana and Madagascar have been reported to apply drones to deliver vital articles such as HIV and TB test kits, birth control, condoms and medical supplies to and from rural areas (Washington, 2018).

Evidence from country studies indicate that the application of drones in medicine have contributed immensely toward rural health care (See for example studies like; Lin, Karishma, Cherie, & Sachin, 2018; Scott & Scott, 2017; Ackerman & Strickland, 2018; Nouvet et al., 2019). Inadequate communication and inaccessible roads in rural areas have been notable barriers to healthcare delivery across Africa. The introduction of drones have partly served as panacea to the ailing healthcare delivery system in Africa. With the introduction of drones in medicine, inaccessible roads are no longer barriers to the delivery and transportation of drugs, blood and other useful healthcare items (Scott & Scott, 2017). It has been noted by Nouvet et al. (2019) that in rural and remote areas in Madagascar, drones are used to control the surge in tuberculosis cases.

Evidence and the qualities of the technological device suggest that drones have the potency of slashing delivery time from days to minutes (Ackerman & Strickland, 2018). Also, it has been argued that prior to its introduction, blood often expired in shelves and banks across many countries in Africa (Glauser, 2018). While curbing blood expiration, drones help to address emergency situations which sometimes lead to loss of lives.

Aside healthcare, the application of drones in Africa has been successful in population and wildlife monitoring, agriculture, archaeology and prevention of genocide (Washington, 2018). Evidence deduced from the South African and

Namibian Defence Forces indicates that eco-drones that use satellites, cameras and predictive analysis are flown over game reserves to control poaching of endangered rhinos and elephants. Concerning the South African rangers, their technological drone device is specifically geared towards the prevention of wild-life extinction (Washington, 2018). Evidence from Morocco also indicates that UAVs are used to track illegal maritime activities and oil spills (Washington, 2018). Drones in Ethiopia release sterile insects (tsetsefly) into certain regions on a weekly basis (Washington, 2018).

Since the implementation of the drone programme became a success, many health stakeholders around the world considered the idea of incorporating same into mainstream health care. Examples include Senegal, Ghana and Canada among others (Glauser, 2018). It is reported that in Senegal, since 2017, the government is assessing the usefulness, health impact and cost-effectiveness of applying drones within the health supply chain (Knoblauch et al., 2019). While information on the Ghanaian government and drone is scant and still remains at its infant state, we have tried to draw some nuggets from various reports on the viability of drones in the mainstream of Ghana's healthcare delivery in the section that follows.

Over the past decades, as a result of its numerous applications, UAVs have become a growing market. It has been reported that within a year, and at the end of April 2016, the purchase of drones among major stakeholders increased exponentially (Lin, Karishma, Cherie, & Sachin, 2018). In a 2016 study, Lin and his contemporaries argued that future application, adoption and use of drones have the potential of reducing waiting time in hospitals. They are of the view that drugs can be delivered at the doorstep of patients for emergency services within few hours (Lin, Karishma, Cherie, & Sachin, 2018). Concerning delivery, it is argued that there is the launch of more than fifty (50) drones daily on the delivery mission of African countries (Glauser, 2018). The capability of drones to navigate using the Global Positioning System (G.P.S.) can enable doorstep delivery (Balasingam, 2017). In a similar manner, Balasingam (2017) proposes robot-like drones to be aided to deliver medication to elderly people in homes (Balasingam, 2017).

It is not a mistake to conclude that in Africa, there are inadequate health centers (Adindu, 2010). The inadequacy of health centres coupled with unpleasant living condition breed pressure on the existing health facilities. Issues surrounding inadequate medical personnel, lack of essential equipment and bed spaces burden almost all medical facilities in the region causing daily traffic among patients who are seeking healthcare. We argue based on the analysis that considering the use of drones for doorstep delivery of essential medical apparatuses including drugs, would contribute to the decrease of traffic in the fragile western-oriented healthcare systems across Africa.

Specific drones for delivery have their varied and specified amount of time and distance they could cover. A renowned drone referred to as the *Parcelcopter (3.0)* has been reported to have the ability to travel for only 5miles (Lin, Karishma, Cherie, &

Sachin, 2018). This type of drone which is a 'compact flying toolbox can contain life-saving supplies such as automated external defibrillator, medication and/or cardiopulmonary resuscitation aids (Lin, Karishma, Cherie, & Sachin, 2018).

The Ghanaian case.

The Ghanaian drone policy was implemented by the government of the New Patriotic Party (NPP) to contribute to addressing Ghana's healthcare fragility. Commencing in April 2019, the vice president of the country launched the world largest medical drone delivery network in the Eastern Region of Ghana (Adu-Gyamfi et al., 2019; Ministry of Health, 2019). Similar to the Rwandan case, the drone service in Ghana was designed and installed –and is currently being controlled- by a US-based Zipline International Inc. in partnership with the Ghana Health Service (Ghana Health Service, 2017).

"Ghana's drone makes on-demand emergency deliveries of 148 different vaccines, blood products and life-saving medications to health facilities in the country, 24 hours a day" (VOA, 2019). Evidence suggests that the New Tafo hospital in the Eastern Region of Ghana was the first health facility to receive the services of the drone. Within this hospital, a 7year old boy was admitted and needed a blood transfusion of O-negative. Within some few minutes the item was delivered by drone (VOA, 2019).

At inception, the government reported that the sole aim for introducing the drones in Ghana's healthcare system was to leverage technology to advance the supply chain of critical medical supplies. Earlier information suggests that the delivery of these critical and vital supplies by the drone has the tendency to reduce time-wasting and save lives (GHS, 2017). The project, entitled *'fly-to-save-a-life'*, has been a 24-hour health delivery system which is expected to make on-demand delivery of medical needs to about 2000 health facilities –including those in rural areas (Ministry of Health, 2019). Importantly, the introduction of medical drone is motivated by government's goal to bridge the over-stretched gap in medicine or healthcare between urban and rural areas. The above was envisaged to enhance the achievement of a Universal Health Care delivery system among Ghanaians (Ministry of Health, 2019). To that extent, government has sought to make healthcare equitably distributed to both rural and urban populace.

Over the years, Ghana has been burdened with maternal mortality. While the partial improvement of healthcare logistics and the introduction of healthcare programmes have eased the burden of maternal mortality, the pace appears to be slow as the country still faces the burden (Apanga & Awoonor-Williams, 2018). Statistics indicate that Ghana's maternal mortality ratio has declined from 760 per 100,000 live births in 1990 to 319 per 100,000 in 2015 (Apanga & Awoonor-Williams, 2018). This has shown a growing pace towards the achievement of the aspects of Millenium Development Goals (MDGs) that focus on maternal health.

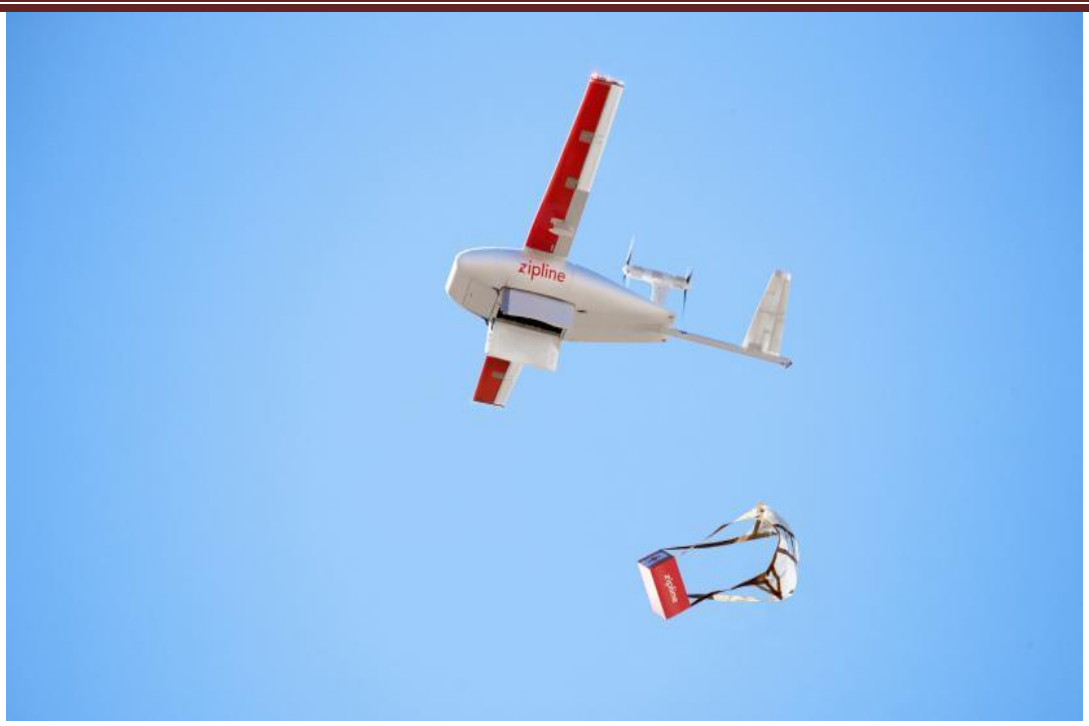

Figure 6. A Medical Drone Making delivery in Ghana[5] (Rayner, 2019).

To hasten governments aim to yield the expected results of 70 per 100,000 live births by 2030, the government of Ghana thought that it is expedient to apply drones to maternal health. In a presidential address to the nation, the Vice President retorted that the drone project would help reduce maternal mortality. The application of drones include, to transport blood within few minutes or hours to labour wards (Ministry of Health, 2019). Also, the United Nations Population Fund (UNPF) and the Dutch government hoped to address access to women's health clinics in Ghana with drones. Their activities included using drones to deliver contraceptives and other gynaecological supplies to women in rural areas within Ghana (Rosser, Vignesh, Terwilliger, & Parker, 2018). Aside maternal health, the implementation of the drone policy has yielded positive results in addressing complications such as snake bites, accidents and other life threatening emergencies (Ministry of Health, 2019).

The Medical Drone during the Era of COVID-19.

As a result of Africa's healthcare fragility (Adindu, 2010), many stakeholders of health became concerned about the impact COVID-19 could wreak on the continent. Concerning Ghana, a country with less than one hundred ventilators, at the inception of the virus, the projection of fatality rate was beyond measure. Any success story achieved by Ghana during the COVID-19 outbreak could be partly attributed to the use of medical drones. Due to the use of medical drones, other essential services to meet

[5] The Drone above is known as Zips and was invented by a US robotics company, Zipline. Among other things, the device can transport up to 1.5 kg of blood over 150 km (Rayner, 2019). It has been suggested by Rayner that, "the drones will be able to ferry 150 different medicines and vaccines, as well as blood, to more than Ghanaian clinicians, covering 12 million people."

other pressing health needs were not curtailed. The fight against COVID-19 should be explored by countries in future epidemics and pandemics.

As a delivery device, Ghana's medical drones have been used to transport and expedite COVID-19 test swabs to -and fro- research centers (Konert, Smereka & Szarpak, 2019; Baker, 2020). Initially, the country relied on ambulatory services to deliver test samples, test tubes and important articles such as Personal Protective Equipment (PPEs) to health facilities and health workers. The reliance on ambulatory services, although useful, witnessed a myriad of challenges. This included barriers to transportation due to inaccessible roads and time factor. Originally, it could take up to five (5)n days to get results for test samples.

Baker (2020) is of the view that Ghana's application of medical drones was reported as the first time of applying such device drones to the fight against COVID-19. Concerning its application, it was reported that:

…As the Municipal Director of Health Services for a rural district of Ghana, Sarkodie had ordered an entire camp of 244 construction workers into quarantine when three of them tested positive for the novel coronavirus…on April 17, instead of driving the test swabs two hours to the capital, Accra, for analysis, he had them dropped off at a health facility one district over. Within a few minutes, they were winging their way to a testing facility via autonomous drone… Two days later, the results came back via SMS: negative. The workers could be let out of quarantine (Baker, 2020).

The reliance on drone for the fight against the pandemic proved very effective and worthy. Significantly, Ghana was able to save hours and days from the time it took to get COVID-19 test from suspected rural victims to the urban areas (Baker, 2020). On average, Zipline's fleet in Ghana was tasked to transport up to 15,000 tests a day in 300 flights (Baker, 2020). The drones also transported vital supplies such as PPEs to health workers across the country. Subsequently, Zipline considered applying same technological advancement in America (Baker, 2020). The use of the drone for delivery mission can equally be applied to several arenas of development as time unfolds.

Conclusion.

Access to healthcare has been a major challenge to Africa and Ghana in particular. The discourses on the history of medicine and healthcare in general have highlighted the threats and challenges of extending scientific medical services and healthcare in general to rural and remote areas in certain parts of the African continent. Inaccessible roads, time factor and lack of essential materials in rural healthcare centers have generated grave concerns among stakeholders.

Drawing on a compendium of internet and journal articles, we have discussed the application of drones in the mainstream of the medical systems in Africa in general and Ghana in particular. Findings from the current study indicate that drones, otherwise known as, Unmanned Aerial Vehicles (UAVs) have become a growing market over the years. First, it was used by states as a military weapon, the device has been applied

to different sectors of the economy including health. With its sole responsibility to deliver items, stakeholders of health across several parts of the world have relied on the device to transport vital articles among health centers. Concerning Africa, countries like Senegal, Madagascar, Rwanda and Malawi encouraged Ghana to consider the application of drones in her mainstream healthcare delivery system.

Since its inception in Ghana's medical care, important medical/health kits such as test samples, blood and PPEs to be distributed to various health centres with rural areas being the prime concern. The contribution also paid attention to the application of medical drones to the fight against the current Coronavirus burden in Ghana. The country under study has deployed the medical drone to deliver COVID-19 test samples and PPEs to health workers across the country.

We argue that the introduction of medical drones in Africa and Ghana in particular can create the opportunity to bridge the over-widened gap in healthcare between the rural and urban population. The introduction of the drone has demonstrated potential resilience against several barriers. It has demonstrated that it has the ability to be used within several aspects of human endeavours. To this end, future research needs to explore similar areas where the device can be applied; in particular, the concentration should be based on empirical data.

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The authors declare no conflict of interest.

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Історізація медичних дронів в Африці: в центрі уваги Гана

Анотація. *Хоча походження технології роботи дронів до кінця не вивчено, зрозуміло одне: вони виникли як військовий апарат і привернули велику увагу під час великих воєн, включаючи дві світові війни. Крім використання в бойових діях і для надання гуманітарних послуг, дрони також широко використовувалися для знищення як солдат, так і мирних жителів. Революційно технологія дронів була вдосконалена в XIX столітті, з'явилася можливість ними управляти як безпілотними літальними апаратами, призначеними головним чином для націлювання на війська. Нова сфера застосування безпілотних літальних апаратів – це сектор охорони здоров'я. З роками сектор охорони здоров'я все більше покладається на пристрої для своєчасного транспортування предметів першої необхідності по всьому світу. З моменту його появи в сфері охорони здоров'я вчені намагалися розглянути вплив дронів на охорону здоров'я в Африці і світі в цілому. Серед іншого, вчені з'ясували, що пристрій здатний долати погодні обмеження, брак персоналу в недоступних місцях в секторі охорони здоров'я. Незважаючи на це, даних про дрони і їх застосуванні в Гані, в секторі охорони здоров'я, зокрема, мало представлені в літературі. Крім того, вчені не робили особливих спроб висвітлити використання дронів в африканських країнах. У цьому дослідженні робиться спроба заповнити вказаний вище пробіл, використовуючи підхід описового огляду. При такому підході було проведено ретельний пошук літератури для пошуку і оцінки наукових матеріалів, що стосуються застосування дронів у військовій області і, зокрема, в медичних системах Африки і Гани. Несучи одноосібну відповідальність за доставку*

предметів, зацікавлені сторони в області охорони здоров'я, в декількох частинах світу покладалися на безпілотні літальні апарати для транспортування життєво важливих предметів у медичні центри. Такі країни, як Сенегал, Мадагаскар, Руанда і Малаві, закликали Гану розглянути питання про застосування дронів в її основних медичних послугах. Результати дослідження показали, що прийняття Ганою політики використання безпілотних літальних апаратів, поліпшило своєчасну доставку таких продуктів, як зразки для аналізу, крові і засоби індивідуального захисту, в різні медичні центри і, зокрема, в сільські райони. Дрони внесли свій вклад в забезпечення медичної допомоги в Гані. Ми прийшли до висновку, що завдяки політиці безпілотних літальних апаратів континент має тенденцію досягати успіхів щодо зменшення надмірно збільшившогося розриву в сфері охорони здоров'я між сільським і міським населенням.

Ключові слова: *дрони; медичні безпілотники; Африка; Гана; безпілотні літальні апарати; безпілотна повітряна система*

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Историзация медицинских дронов в Африке: в центре внимания Гана

Аннотация. *Хотя происхождение технологии работы дронов до конца не изучено, понятно одно: они возникли как военный аппарат и привлекли большое внимание во время крупных войн, включая две мировые войны. Помимо использования в боевых действиях и для оказания гуманитарных услуг, дроны также широко использовались для уничтожения как солдат, так и мирных жителей. Революционная технология дронов была усовершенствована в XIX веке, появилась возможность ими управлять как беспилотными летательными аппаратами, предназначенными главным образом для нацеливания на войска. Новая развивающаяся область применения беспилотных летательных аппаратов – это сектор здравоохранения. С годами сектор здравоохранения все больше полагается на устройства для своевременной транспортировки предметов первой необходимости по всему миру. С момента его появления в сфере здравоохранения ученые пытались рассмотреть влияние дронов на здравоохранение в Африке и мире в целом. Среди прочего, ученые выяснили, что устройство способно преодолевать погодные ограничения, нехватку персонала*

в недоступных местах в секторе здравоохранения. Несмотря на это, данных о дронах и их применении в Гане, в секторе здравоохранения, в частности, мало представлены в литературе. Кроме того, ученые не предпринимали особых попыток осветить использование дронов в африканских странах. В настоящем исследовании делается попытка восполнить указанный выше пробел, используя подход описательного обзора. При таком подходе был проведен тщательный поиск литературы для поиска и оценки научных материалов, касающихся применения дронов в военной области и, в частности, в медицинских системах Африки и Ганы. Неся единоличную ответственность за доставку предметов, заинтересованные стороны в области здравоохранения в нескольких частях мира полагались на беспилотные летательные аппараты для транспортировки жизненно важных предметов в медицинские центры. Такие страны, как Сенегал, Мадагаскар, Руанда и Малави, призвали Гану рассмотреть вопрос о применении дронов в ее основных медицинских услугах. Результаты исследования показали, что принятие Ганой политики использования беспилотных летательных аппаратов, улучшило своевременную доставку таких продуктов, как образцы для анализа, кровь и средства индивидуальной защиты, в различные медицинские центры и, в частности, в сельские районы. Дроны внесли свой вклад в обеспечение медицинской помощи в Гане. Мы пришли к выводу, что благодаря политике беспилотных летательных аппаратов континент имеет тенденцию добиваться успехов в отношении чрезмерно увеличившегося разрыва в сфере здравоохранения между сельским и городским населением.

Ключевые слова: *дроны; медицинские беспилотники; Африка; Гана; беспилотные летательные аппараты; беспилотная воздушная система*

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The history of the creation of lasers and analysis of the impact of their application in the material processing on the development of certain industries

Abstract. *The paper is devoted to the analysis of the history of the creation of the laser as one of the greatest technical inventions of the 20th century. This paper focuses on establishing a relation between the periodization of the stages of creation and implementation of certain types of lasers, with their influence on the invention of certain types of equipment and industrial technologies for processing the materials, the development of certain branches of the economy, and scientific-technological progress as a whole. In preparing the paper, the generally accepted methods, which are widely used in the preparation of historical research works, have been applied: the historical method – for the study and interpretation of the texts of primary sources and the search for other evidence used for research, as well as for the presentation of historical events associated with the development of laser technology; the historical-genetic method – for studying the genesis of specific historical phenomena and analyzing the causality of changes in the development of laser technology; the historical-critical method – for displaying cause-and-effect relationships, reconstructing events that influenced the development of laser technology; the method of historical periodization. The variety of different possible options for the use of lasers did not allow placing all the collected materials within the framework of one paper, and therefore, the authors have decided to dwell on the facts, which, in the opinion of the paper's authors, are the most interesting, significant, poorly studied, and little known. The paper discusses the stages of: invention of the first laser; creation of the first commercial lasers; development of the first applications of lasers in industrial technologies for processing the materials. Special attention is paid to the "patent*

wars" that accompanied different stages of the creation of lasers. A comparative analysis of the market development for laser technology from the stage of creation to the present has been carried out. It has been shown that the modern market for laser technology continues to develop actively, as evidenced by the continued stable growth of laser sales over the past 10 years. This indicates that the demand for laser technology is inextricably linked with the development of high technology production and scientific-technological progress. The analysis has shown that recently, the trends in the use of laser technology have changed; in particular, their industrial and medical applications are decreasing, while there is an increase in their use in the fields of sensor production and communication.

Keywords: *laser; history of lasers; Theodore Maiman; National Museum of American History; laser market; laser applications*

Introduction.

The 20th century was rich in great inventions, one of which, undoubtedly, was the laser. At the same time, a laser is just a device or a so-called "tool" whereby it became possible to carry out various actions, which ultimately led to the desired result. The creation of some types of lasers has contributed to the invention of not only new types of apparatuses, devices, but also the emergence of new technological processes and even entire branches of science and industry (Belforte, 2010; Hecht, 2010; Hess, 2013; Ion, 2005; Rigby, 2010). This paper is devoted to this direction, namely, the analysis of the influence of the invention and the stages of the subsequent introduction of certain types of lasers on the stages of development of certain processes, types of technology and industries.

The purpose of the paper is to establish a relation between the periodization of the stages of creation and implementation of certain types of lasers, with their influence on the invention of certain types of equipment and technologies, the development of certain branches of the economy, and scientific-technological progress as a whole.

Research methods.

The authors of this paper have many years of experience in operating various types of lasers, which they acquired by developing various technologies for laser processing of materials (Bernatskyi, Berdnikova, Klochkov, Sydorets, & Chinakhov, 2019; Bernatskyi, Sydorets, Berdnikova, Krivtsun, & Chinakhov, 2020; Khaskin, Bernatskyi, Siora, & Nikulin, 2011; Markashova, Berdnikova, Bernatskyi, Sydorets, & Bushma, 2019; Shelyagin et al., 2005a; Shelyagin et al., 2005b; Shelyagin et al., 2018; Siora & Bernatskyi, 2011). Interest in the history of the stages of creation and implementation of certain types of lasers was the impetus for writing this work. In preparing the paper, the generally accepted methods, which are widely used in the preparation of historical research works, have been applied (Choudhury Kaul, Sandhu & Alam, 2019; Storozum et al., 2019; Strelko et al., 2019a; Strelko et al., 2019b; Van Lent & Durepos, 2019; Zhang & Liu, 2019): the historical method – for

the study and interpretation of the texts of primary sources and the search for other evidence used for research, as well as for the presentation of historical events associated with the development of laser technology; the historical-genetic method – for studying the genesis of specific historical phenomena and analyzing the causality of changes in the development of laser technology; the historical-critical method – for displaying cause-and-effect relationships, reconstructing events that influenced the development of laser technology; the method of historical periodization. The variety of different possible options for the use of lasers did not allow placing all the collected materials within the framework of one paper, and therefore, the authors have decided to dwell on the facts, which, in the opinion of the paper's authors, are the most interesting, significant, poorly studied, and little known.

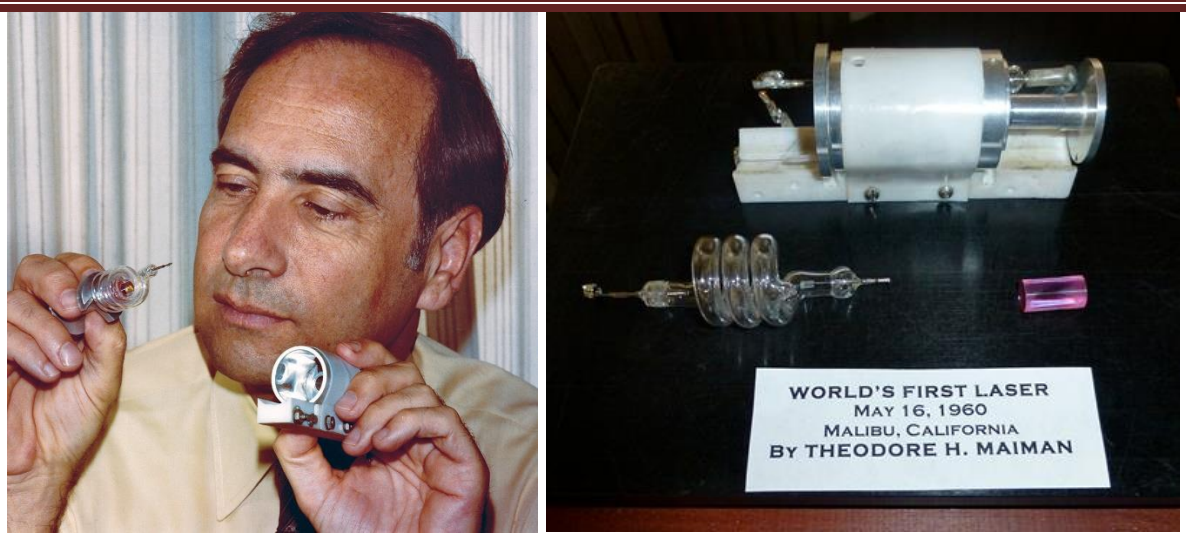
Results and discussion.

The beginning. First generation of laser radiation. Press conference by Theodore Maiman. Finding the first laser applications.

It is a well-known fact that the first generation of laser radiation on a ruby crystal was obtained on May 16, 1960, by Theodore Harold Maiman, who was then at Hughes Research Laboratories, the research arm of the Hughes Aircraft Company (Figure 1). However, the facts that preceded and took place immediately after this event are little known.

Above all, while fighting to fund his research, Theodore Maiman faced serious competition for the primacy of his discovery (Rigby, 2010). When he submitted his paper to Physical Review Letters, it was rejected as "just another maser paper". Maiman quickly wrote a shorter 300-word version of his paper and submitted it to Nature, where it was accepted (Maiman, 1960). As a scholar, Maiman wanted to publish his paper first, but Hughes Labs executives were nervous as the Bell Labs team could be very close to a similar result. Therefore, before Maiman's Nature paper was published, Hughes Labs decided to hold a press conference that was scheduled for July 7, 1960. The photographer hired to shoot the first laser was not impressed – it was too small (see Figure 1.a).

After inspecting the lab, the photographer picked up a later prototype with a medium-sized flashtube and a 5 cm long ruby rod (Figure 2) (Rigby, 2010). The photographer told Maiman, "Hold this in front of your face and I know this will be picked up by every news outlet, but if we print this, this first laser, it won't go anywhere". The photographer was right. The day after the press conference, all major newspapers published this photo. The headlines of papers about the laser invention were calculated to be a big sensation, for example, the Los Angeles Herald published an article with the headline "L.A. man discovers science-fiction death ray", and Newsweek published an article with the headline "This might very well be the of the death ray".



a *b*

Figure 1. Theodore Maiman *(a)* (Rigby, 2010) with the first laser prototype *(b)* (Theodore Maiman – Wikipedia).

Figure 2. The photograph issued at the 7 July 1960 Hughes press conference showing Maiman with a later prototype laser – not the first one (Rigby, 2010).

The further fate of the first sample of the ruby laser created by Theodore Maiman is interesting. The National Museum of American History has photographs of one of the possible versions of Theodore Maiman's first ruby laser (Figure 3) (National Museum of American History).

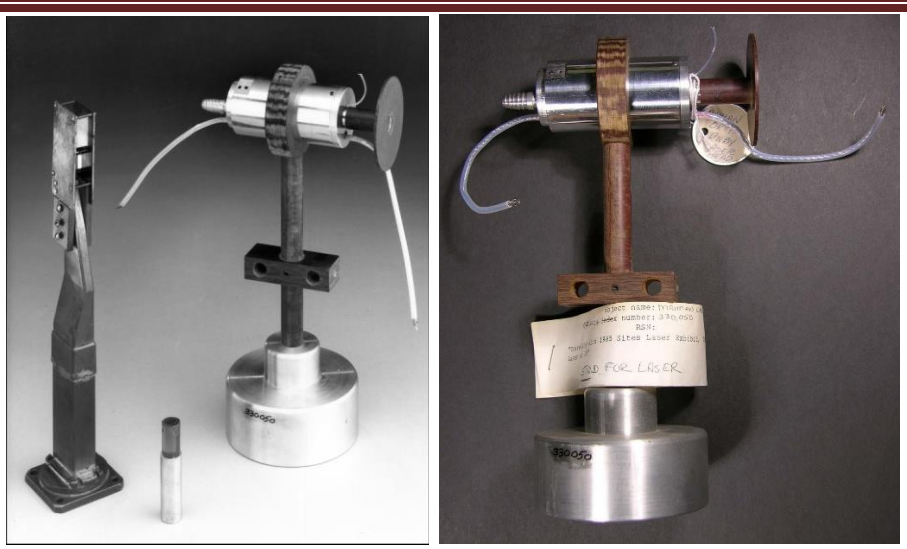


Figure 3. Photographs of one of the possible versions of Theodore Maiman's first ruby laser (National Museum of American History).

By May 1960, Theodore Maiman and Irni D'Haenens at the Hughes Aircraft Company had constructed several small metal cylinders (National Museum of American History). Each of them contained a spiral-shaped xenon flashtube that surrounded a small cylindrical crystal of synthetic ruby. When they lit the flashtube, a flash of light caused the ruby crystal to emit a precisely focused pulse of light – the first emitting laser. Hughes Aircraft donated this and several other Maiman devices to the National Museum of American History Smithsonian Institution in 1970. The crystal inside this device is from the 1961 experiment. Although donation records indicate that this is the first laser, Maiman wrote that he received the first laser as a gift when he left the company in April 1961. During the research, several experimental models were made, which is common practice. Thus, we may never know which device actually generated the first laser beam.

Shortly after Maiman built the first laser, his assistant Irni D'Haenens joked that the laser was "a solution looking for a problem" (Hecht, 2010). As with any good joke, there was an element of truth in this phrase. The laser was not a device invented for specific applications. It was more of a discovery than an invention, using the method for generating coherent light that laser designers expected to find applications in a wide range of fields.

Interesting is the vision of Theodore Maiman himself about the promising areas of application of the laser he created. At the aforementioned press conference on July 7, 1960, Maiman noted the following directions (Shakir & Patel, 2017):

1. The first true amplification of light;

2.A tool to probe matter for basic research;

3. High-power beams for space communications;

4. Increasing the number of available communication channels;

5. Concentrating light for industry, chemistry and medicine (Shakir & Patel, 2017).

It is known that at the press conference, Maiman deliberately tried to avoid discussion about the possible use of lasers as weapons. But after all, he admitted that he could not rule out this option. Maiman's success has inspired other developers and convinced everyone that it was indeed possible to generate laser radiation. This event has filled the laser research community with new energy and new funding. In fact, the concept and design of the Maiman laser was so simple that a few weeks later, its results were replicated by several other researchers, most notably Bell Labs, who demonstrated their version of the ruby laser on August 1, 1960.

Soon after the first demonstration of the laser operation, the search for directions of their practical application began. In 1960–1962, a large number of new laser development companies: Sylvania, Martin Marietta, RCA, Perkin-Elmer, as well as companies that previously produced masers, such as Hughes Aircraft, American Optical, Technical Research Group (TRG), AT&T, Bell Labs, Raytheon, Quantatron, Korad Inc., etc., were engaged in the production of lasers.

Hecht (Hecht, 2010) briefly describes the first attempts to apply lasers in various industries:

> *...Bell Labs management saw coherent light as a technology that increase the capacity of the Bell System's backbone telephone network, which in 1960 consisted of chains of microwave relay towers. Plans were already in the works to upgrade the long-distance network to buried millimeter waveguides carrying signals at 60 GHz, but Bell had long-term plans to upgrade the telephone system from voice to video, which would require much more bandwidth. Optical frequencies were more than a thousand times higher, so they promised the needed bandwidth.*
>
> *The Pentagon wanted a new generation of weapons. Deeply unsettled by the 1957 Sputnik launch, the Eisenhower administration created the Advanced Research Projects Agency (ARPA, now DARPA) to invest in high-risk, high-payoff research that other military research agencies had been unwilling to support. Soon after ARPA opened its doors, its first director, Roy Johnson, told Congress he would fund anything that might reduce the threat of nuclear attack, even "death rays." When TRG asked for $300,000 to try to build a laser using Gould's ideas, ARPA instead gave them $999,000, hoping for applications in target designation and communications, as well as in missile defense.*
>
> *Physicians began testing lasers to see if they could treat ailments better than other light sources, particularly in dermatology and ophthalmology, where light was already widely used. The first important laser success was in ruby-laser treatment of detached retinas. Previously, ophthalmologists had focused light from 1000 W arc lamps into the eye for 1-s intervals to form scars attaching the retina to the eyeball. The procedure had to be re-engineered to use millisecond laser pulses, but it worked in rabbits, and ophthalmologist Charles J. Campbell treated the first human patient at the Harkness Eye Institute of Columbia University on November 22, 1961. About a week later, Christian Zweng*

performed a similar operation in Palo Alto, California. Both operations were successful.

Physicists focused laser beams to high intensity to study laser-matter interactions. In 1961, Peter Franken focused 3 J ruby pulses into quartz and generated the 347.2 nm second harmonic, which appeared as a faint spot on a photo recorded after passing the light through a spectrometer. He and three University of Michigan colleagues called the faint spot an "unambiguous indication of second harmonic," but that didn't stop someone at Physical Review Letters from thinking the spot was a flaw in the photo and editing it out. The Lawrence Livermore National Laboratory wondered about prospects for laser-induced nuclear fusion, and in 1962 formed a group to study the prospects seriously (Hecht, 2010).

First problems. Commercialization of the laser development. "Patent Wars".

Manufacturers and companies that tried to apply lasers in different industries had faced the problem of measuring the power of laser radiation. The first ruby lasers produced very powerful pulses – too powerful to be measured with most optical sensors of the time (Mueller, 2010). Researchers placed razor blades in front of the lasers and counted how many blades the laser could drill. This unofficial unit of measurement is called Gillette. The first Maiman's laser produced 1 Gillette pulse. Within a few months, his competitors were assembling a laser with a power capable of burning through 4 Gillette. Today, spot laser welding of stainless steel blades and spring-loaded support rods has become the gold standard for shaving sticks, with laser welding productivity reaches 120,000 single-spot welds per hour (Laser spot welding).

Already in 1961, a new global industrial market – the laser market – has emerged. Initially, the companies produced one-off and small-scale products, and because of this, the cost of the first lasers was relatively high. According to (Hess, 2013), the first commercial laser was manufactured by Raytheon and sold for $ 5,850 at a meeting of the Institute of Radio Engineers in New York in March 1961. This LH-1 pulsed ruby laser (Figure 4) had a housing designed for easy rod and lamp replacement and it operated at room temperature.

The evidence that the first commercial laser was manufactured and sold by Raytheon in 1961 is corroborated in the paper by George J. O'Neill (O'Neill, 1983).

However, Klauminzer (Klauminzer, 1984) claims that a 1 mW helium-neon laser (He-Ne) was the first to be sold by Spectra-Physics in 1962 for $ 7,500.

The authors are interested in facts about the development of laser production by its discoverers – Theodore Maiman and Hughes Aircraft Company.

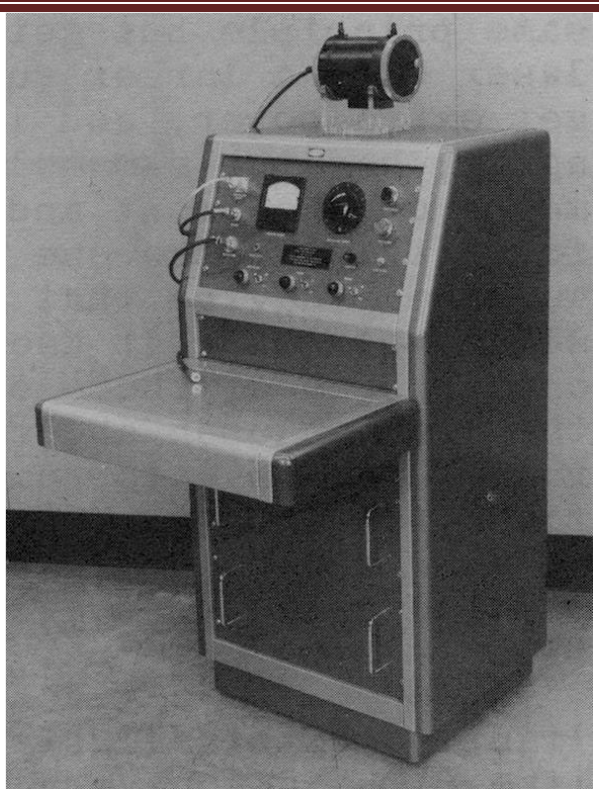


Figure 4. 1961 Raytheon LH-1 pulsed ruby laser system, the first laser model sold commercially (Hess, 2013).

Theodore Maiman was one of the first, initially setting up a laser group at a short-lived company called Quantatron in Santa Monica, California, then taking his laser group to form the core of Korad Inc., also in Santa Monica, with funding from Union Carbide (Hecht, 2010). Korad soon began making ruby lasers based on Maiman's design, as shown in Figure 5.

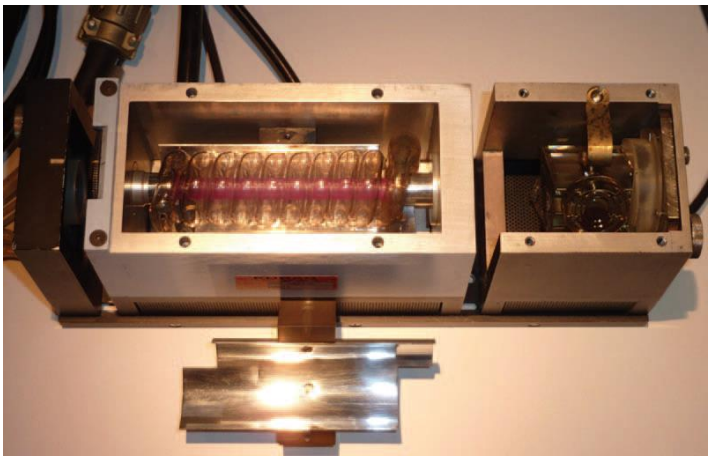


Figure 5. Korad's first commercial ruby laser, serial #001 of model RL-4KCS. The box at the right is a liquid Q switch. Comparison with that Maiman's original design has been modified byusing a longer flashlamp with with more coils and a longer rod (Hecht, 2010).

The Hughes Aircraft Company introduced its first commercial laser only in May 1962, despite having built the first laser two years earlier (Anonymus, 1962). This Model 200 pulsed ruby laser was a commercial version of Maiman's first device, but with a longer rod, at the ends of which dielectric mirrors were applied (Figure 6) (Hess, 2013).

Figure 6. 1962 Hughes Aircraft Company model 200 ruby laser system, fully operational with all original components (Hess, 2013).

In general, in the history of the laser technology development, it is rather difficult to track the primacy of an invention or application in a particular industry. This is due to the fact that manufacturing companies were in no hurry to reveal all the secrets and ideas behind their laser designs. Moreover, a large amount of work was carried out by order of the military departments, which in itself implied a regime of increased secrecy.

In this regard, in the field of the laser technology invention and the use of laser technologies, there have always been a fairly large number of disputes, which have repeatedly escalated into legal proceedings that dragged on for many years.

The most famous is the opposition (or the "Thirty Years Patent War") of Gordon Gould with the United States Patent and Trademark Office for obtaining patents for laser and related technologies. He also fought laser manufacturers in lawsuits to protect the patents he later received. Gordon Gould is the author of the acronym LASER (Light Amplification by Stimulated Emission of Radiation) (Taylor, 2000, pp. 66–70). The thirty-year patent war that it took for Gould to win the rights to his inventions has become known as one of the most important patent battles in history. On October 11, 1977, after nearly 30 years of the "patent war", Gordon Gould obtained a patent for optical pumping, which was later used in about 80% of lasers. As a result, Gould was granted 48 patents, the most important of which were patents for optical pumping,

collisional pumping, and application patents (Taylor, 2000, p. 70). However, these technologies covered most of the lasers that were in use at the time. For example, the first operating laser, a ruby one, was optically pumped; the helium-neon laser is pumped by a gas discharge.

Even the inventor of the first ruby laser, Theodore Maiman, was able to obtain a patent for his laser only in 1967, having bought it for $ 300 from the Hughes Aircraft Company (Maiman, 2018, p. 191).

In this regard, the work of Dutta Majumdar and Manna (Dutta Majumdar & Manna, 2003), in which they tried to systematize and to compare the invention and commercialization of the idea (or application) of different types of lasers, is interesting.

Probably the most heated argument among researchers of the history of lasers is about the fact of the first industrial application of lasers.

Laser Processing of Engineering Materials (Ion, 2005, p. 20) states that the first laser welds were made around 1963, and involved butt and edge joints in 0.25 mm stainless steel foils, processed with a pulsed ruby laser (Platte and Smith, 1963). Welds were also made between gold connecting leads and aluminium-coated silicon surfaces in microelectronic devices. The laser beam was merely being used to fuse material, albeit very accurately, in a conduction-limited mode. Other reports of research into conduction-limited welding in metals were published (Fairbanks & Adams, 1964) and applied to joining wires, sheets and circuit boards shortly afterwards (Anderson & Jackson, 1965; Cohen, Mainwaring, & Melone, 1969; Conti, 1969), when 0.5 mm was considered to be an upper limit of penetration. The first industrial application appeared around 1965, when a pulsed Nd:YAG laser was used to repair broken connectors inside assembled television tubes (Belforte, 1993, p. 5 as cited in Ion, 2005). Ruby laser welding was used in fabrication of the first Apollo lunar sample return containers in 1969 (Moorhead, 1971). Various laser-based conduction joining techniques have been developed, including soldering and brazing, partly in response to the needs of the microelectronics industries. The first CNC laser soldering machine, based on a 50 W CO_2 laser was produced commercially in 1976 (Loeffer, 1977).

However, as we have shown earlier, there is a lot of information that is difficult to systematize and subject to thorough analysis in the history of the development and application of laser technology. Perhaps for this reason, some literature sources provide data that does not match the above data and the data of Dutta Majumdar and Manna (Dutta Majumdar and Manna, 2003). For example, George J. O'Neill (O'Neill, 1983) показывает, что в 1962 in a vivid demonstration of the laser's intensity, Professor Louis Smullin, a physicist at the Massachusetts Institute of Technology, used a system developed by the Raytheon Corporation to bounce a powerful ruby laser beam off the moon, 400,000 kilometres (250,000 miles) away. The size of the spot that hit the moon's surface was an estimated 64 kilometres (40 miles) in diameter. By contrast, the beam of a searchlight powerful enough to reach the lunar surface would be spread over thousands of miles.

Table 1. Commercially available lasers and their industrial applications (Dutta Majumdar & Manna, 2003).

Laser	Year of discovery	Commercialised since	Application
Ruby	1960	1963	Metrology, medical applications, inorganic material processing
Nd-Glass	1961	1968	Length and velocity measurement
Diode	1962	1965	Semiconductor processing, biomedical applications, welding
He–Ne	1962		Light-pointers, length/velocity measurement, alignment devices
Carbon dioxide	1964	1966	Material processing-cutting/joining, atomic fusion
Nd-YAG	1964	1966	Material processing, joining, analytical technique
Argon ion	1964	1966	Powerful light, medical applications
Dye	1966	1969	Pollution detection, isotope separation
Copper	1966	1989	Isotope separation
Excimer	1975	1976	Medical application, material processing, colouring

For example, the paper by Melinda Rose and Hank Hogan (Rose & Hogan, 2019) argues that in 1962, a laser was first used to weld watch springs. This could be considered one of the first (if not the first) applications of lasers for metal processing in the industry, but in other sources, this information does not find enough convincing evidence.

Belforte (Belforte, 2010), argues that the first practical, value-added industrial application for the ruby laser invented by Ted Maiman was the drilling of cooling holes in aircraft engine turbine blades. As the operating temperature of these engines increased it was necessary to find a way to cool the blades to prevent thermal damage.

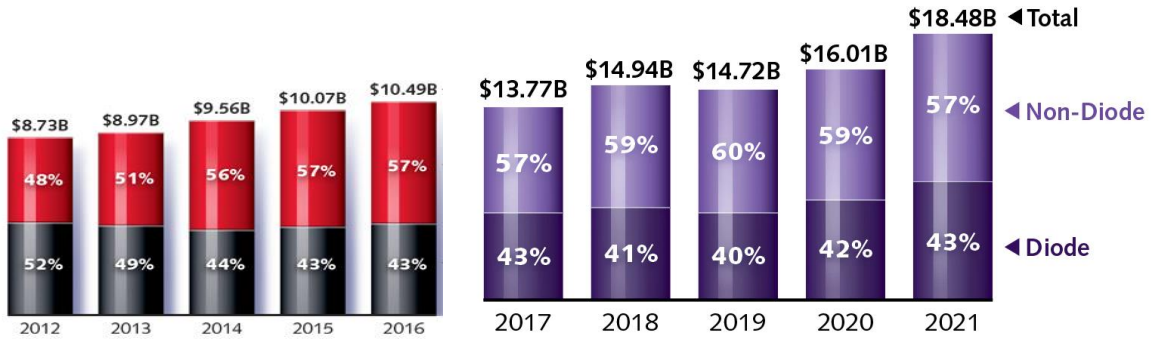
Laser market. Its formation, development, and modern stage.

Anyway, the laser market has been rapidly developing since the early 1960s. In 1980, it was already $ 500 million, according to the authoritative edition of Laser Focus World cited in George J. O'Neill (O'Neill, 1983).

The current market for laser technology is already a completely different amount and sales volume.

Figure 7 (Holton, Overton, Nogee and Belforte, 2016; Holton & Nogee, 2021) presents data from the authoritative Laser Focus World, which shows how the laser market has changed in recent years.

As seen in Figure 7, laser manufacturers have earned about $ 16 billion in 2020.



a *b*

Figure 7. Laser market in 2012–2015 *(a)* (Holton, Overton, Nogee & Belforte, 2016) and in 2017–2020 and forecast for 2021 *(b)* (Holton and Nogee, 2021).

As can be seen from the data in Figure 7, the market for lasers themselves (excluding technological and auxiliary systems, manipulators, and similar equipment) almost doubled and grew practically all the time (except for 2019) constantly and steadily, despite the consequences of global trade conflicts, weak business investments, and COVID-2019, which certainly put pressure on the global economy and increase the risk of long-term stagnation.

In his publication, Andreas Thoss explains this phenomenon in this way (Thoss, 2021):

> *...2020 was a difficult year for the global economy, but laser markets did surprisingly well. Allen Nogee, President of Laser Markets Research, said that there are at least two different reasons for this resilience in laser markets, as noted in his annual review and forecast of the worldwide laser market. First, lasers are often built into capital goods, and such investments are not made or canceled on short notice. The second reason was the relatively fast recovery of the most important market for lasers and laser systems – China. This logic has been reflected by global and national statistics. The GDP of the U.S. fell 3.6% in 2020; in Europe, it went down 7.4%; while in China, it grew 2.3%. At the same time, the global laser market grew at a remarkable pace of 8% to $16 billion (see figure 3). While the uncertainty of the pandemic remains, Nogee presented an*

optimistic outlook for 2021. On the macro-economic side, he expects above-average growth in the U.S. (3.5%), Europe (3.6%), and China (7.9%). In fact, 2021 could show the highest growth rate in these regions in more than three years. Similarly, the laser market would expand by 10.4% to $18 billion in 2021 (Thoss, 2021).

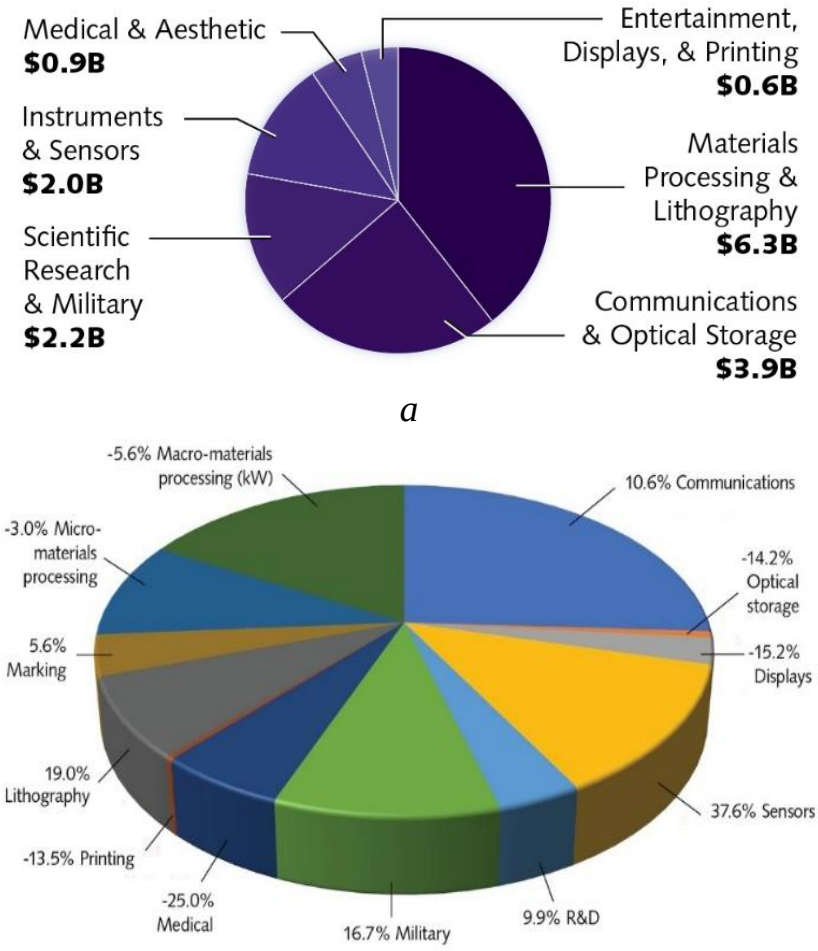


Figure 8. The chart showing the distribution of laser sales in 2020 by the most demanded industries *(a)* (Holton & Nogee, 2021) and the percentage distribution of laser sales in 2020 *(b)* (Thoss, 2021).

Figure 8.a (Holton & Nogee, 2021) is a chart that shows the distribution of these laser sales by the most demanded industries. Figure 8.b (Thoss, 2021) has a chart that shows the percentage distribution of laser sales in 2020. A “minus” sign for various applications indicates a decline in sales relative to 2019 results.

Historical milestones in the creation and improvement of certain types of lasers and laser technologies for industrial processing of materials.

The charts above show pallid statistics. They in no way convey all the drama of the creation, development, and improvement of the aforementioned laser technology.

The authors believe that the areas of laser application shown in Figure 8 are worthy of special mention in the context of their invention and improvement of both laser design and technological applications. Limited to the maximum possible volume of publication, the authors have decided to focus on the consideration of little-known historical facts related to the production and operation of lasers for industrial processing of materials.

Mikro-materials processing.

Laser precision drilling.

In the conditions of the late 1960s and early 1970s, one of the urgent tasks of this area was a radical increase in productivity in the manufacture of a number of miniature products from crystalline materials on an industrial scale. These, in particular, included: jewel bearings and sliding bearings of special precision instruments, which are made of ruby and sapphire; wire-drawing dies made of natural diamond, necessary for drawing thin wire with a diameter of 10 μm; wire-drawing dies made of artificial diamonds, in which it was necessary to drill and to form shaped holes with a diameter of up to 80–100 μm with a tolerance of only a few microns.

In 1965, the first production laser cutting machine was used to drill holes in diamond dies. This machine was made by the Western Electric Engineering Research Center (Bromberg, 1991, p. 202). This event is mentioned in Raytheon News (Anonymus, 1966, January as cited in Earls & Edwards, 2005, p. 86) (Figure 9).

Page 2 Raytheon News January 1966

Raytheon News
Published by the
RAYTHEON COMPANY
LEXINGTON 73, MASSACHUSETTS
VOLUME 15 JANUARY 1966 NUMBER 1

Western Electric Uses Raytheon Laser In Forming Special Dies from Diamonds

Education Activities Transferred into Commercial Group

Candlepin Tournament To Roll Feb. 6-Mar. 6

First LEM Computer Delivered on Schedule By People of Space Div.

Hobby, Levine Win PRSA Accreditation

Figure 9. Raytheon News. 15(1) (1966). p. 2 (Earls & Edwards, 2005, p. 86).

In 1970, by order of the Boeing Corporation, drilling of numerous fans in turbine blades and parts of the “hot zone” of an aircraft gas turbine engine (GTE) was performed using a pulsed ruby laser for the first time at the plant of the American company General Electric, which significantly increased its resource (Vaks, Milen'kij & Saprykin, 2017, p. 27). By 1974, more than ten advanced Raytheon systems with Nd:YAG-lasers were successfully operating at the production plants of General Electric Ind., the largest manufacturer of aircraft engines for civil and military

aircrafts and for rocket and space equipment at that time. In 1965, Watch Stones Corp., the Swiss manufacturer of ruby stones for watches, signed a contract with the Institute of Applied Physics at the University of Bern to investigate the possibility of laser drilling of holes in ruby boules, thus opening the "laser era" in Switzerland. At the beginning of 1972, ASUAG (since 1983 – SWATCH Group SA), the leading Swiss watch manufacturer, opened a special laser center for the technological study of the problem. In 1974, the center was transformed into LASAG Corp. with the mission of developing laser equipment and laser drilling technology for watch ruby stones for the Swiss and European watch industry.

Drilling holes in heat-resistant and difficult-to-cut materials.

By the mid-70s of the last century, with the rapid development of turbojet aviation, the task of improving the resource and increasing the calibration interval for aircraft engines became particularly acute. Dozens of laser systems from Raytheon (SS-500 and SS-550), Lumonics (JK MS-830), and later – Convergent Energy (Gemini with Aurora P50) have already operated at GE Aircraft Engines, Rolls-Royce, and Pratt & Whitney, etc., for drilling fans in turbine blades of the hot zone and in parts of the combustion chamber of aircraft engines (Vaks, Milen'kij & Saprykin, 2017, pp. 31–32). The number of fans with a diameter of 250 μm to 900 μm and a depth of 3 mm to 10 mm in chrome-nickel heat-resistant and difficult-to-machine alloys reached several hundred per blade and the demand for blades was estimated at hundreds of thousands. With such a mass production, the high speed and productivity of laser drilling superseded the competing processes of electrochemical and electroerosion machining in many factories in a short time. The aerodynamics of the cooling flow of the blade and the complex external and branched internal profile require the arrangement of the fans, according to an individual scheme and at different (including "sharp", up to 15°) angles to the surface. Therefore, processing is carried out on special high-speed 5-axis laser machines with precision kinematics. One of the most modern European factories, MTU Aero Engines, is located in Munich and produces modern aircraft engines, assemblies and sets of blades both for the Airbus S.A.S. (for the A-320 and A-380 aircraft family) and other aircraft manufacturers. Blades and parts are machined in three shifts on six LaserTec 80 PowerDrill machines from Deckel-Macho Group (DMG). The machines are equipped with lasers from Lasag and Rofin-Baasel.

The current stage in the development of laser drilling technologies is closely related to progress in the development and production of industrial-grade diode-pumped solid-state lasers generating nano- and picosecond pulses at high repetition rates.

Laser mikro-cutting of stents.

The fine focusability of laser beams is attractive in mikro-materials processing. An outstanding example -and one that revolutionized an industry so much so that it became the process of choice as world demand increased – is laser cutting of stents,

which started in 1992 (Belforte, 2010). In 1993–1994 a Lumonics low divergence Nd:YAG laser produced limited success cutting stents and was later replaced by a Lasag unit, which became a commonly used laser for this application. Stent cutting, now a major application in the medical devices industry, has been a driver in the introduction of quality, reliable industrial lasers and motion control systems. Flashlamp pumped Nd:YAG lasers were succeeded by diode-pumped units, then disc and fiber lasers, the latter currently the choice for this application. Advanced laser technology in the form of picosecond and femtosecond lasers are being considered for use with the new bioabsorbable stents. Today tens of thousands of stents have been produced worldwide.

Makro-materials processing.

Laser welding.

One of the first laser industrial applications was in welding. The manufacture of mechanical wristwatches has always required maximum precision. It is therefore not surprising that the watch industry relies on laser instruments for almost every node. Haas, a Schramberg-based watchmaker in the German Black Forest region, has pioneered laser welding of wristwatch springs back in 1964 (Quentin, 2017). Welding the watch springs required only low laser power, since the steel springs to be welded were less than one millimeter in size. Shortly thereafter, Haas has begun developing its own laser radiation sources. In 1971, Haas introduced its first proprietary solid-state laser: rod laser on Nd:YAG (neodymium-doped yttrium-aluminum garnet). Beginning in 1992, TRUMPF has begun investing in Haas Laser GmbH to expand its own range of beam sources, which at the time consisted mainly of CO_2 lasers. Since then, Haas Laser has grown into TRUMPF's Schramberg site, where solid-state lasers are developed and manufactured.

High-power CO_2 lasers with good beam quality and reliable output power were the laser of choice for the joining of sheets of steel that are used in automotive body manufacturing (Belforte, 2010). Although the first laser blank weld was done experimentally for British Leyland in 1981 it was the 1983 application for German auto manufacturer Audi who had need for sheets of metal large enough to be stamped into a limousine underbody that lays rightful claim as the first production laser welded blank. No required sheet sizes were available from German steel mills so Thyssen Steel using a Rofin Sinar 1.5 kW CO_2 laser welded two pieces of available size sheet to make the needed size for stamping. Thus was born the laser tailored blank welding business, which today finds laser tailored blank components used by auto manufacturers worldwide. In 1984 Toyota stunned the rest of the global auto industry with the introduction of a laser welded five-piece body side ring for the Camry, which allowed a choice of metal thicknesses to reduce weight and consequently improve fuel economy. As the auto industry's annual demands for tailored blank components increased an increasing number of new blank supplying subcontractors appeared and they asked for and received units with higher power (to 8 kW) CO_2 lasers. The

contribution of laser welded blanks to the design and production of lighter weight and more energy efficient vehicles is immense. The ability to mix steel materials and thicknesses has allowed designers to greatly improve body design and to minimize the number of components needed to meet strict crash standards.

Laser cutting.

The first experiment in laser processing of materials, which later developed into an important industrial process for gas laser cutting of metals, was conducted in May 1967 by Peter Houldcroft, who was then Deputy Scientific Director at The Welding Institute (TWI) in Cambridge, and Arthur Sullivan, who was a laser operator at the Services Electronic Research Laboratory (SERL) in Harlow Houldcroft and Sullivan, using oxygen gas to cut 1 mm steel sheet with a focused CO_2 laser beam. Paul Hilton describes this event in (Hilton, 1997) as follows:

> *...In early 1967 Houldcroft designed a 'laser cutting nozzle', its important feature being the oxygen pressure chamber which would provide the co-axial reactive assist gas stream in the region of the laser beam focus. This nozzle arrangement can be seen in the photograph in Figure 10, which was taken during the first series of cutting trials made during May 1967. The oxygen gas was kept in the chamber by a flat «pressure window», and the beam focusing lens was positioned above the pressure chamber. The design of the nozzle tip itself, which had a circular orifice 2.5mm diameter and used a stand off distance of 1.5mm, is remarkably close to commercial nozzles in use today. The horizontal laser beam was diverted onto the focusing lens by an aluminised steel mirror. The lens (of focal length about 300mm) and pressure window were made from sodium chloride. It was sometime later that potassium chloride was used. The rectangular block at the top right of the photograph was attached to a rotating handle. This in fact formed the laser shutter and beam stop. The results of this work were soon published in the article (A.B.J. Sullivan, P.T. Houldcroft. (1967). Gas-jet laser cutting. British Welding Journal. pp. 443–445) (Hilton, 1997).*

Figure 10. The first oxygen assist gas laser cutting performed in May 1967 (Hilton, 1997).

The American company Boeing is the first one to integrate laser-cutting on its production lines. In August 1969, three employees from the Boeing Company produced a paper on the CO_2 laser cutting off "hard" materials – titanium, Hastelloy and ceramic – using the assist gas technique. They concluded that the laser "could be an effective and economical cutting tool, but a great deal of research and development may be required before such a machine could be put on the production line". In the 1970's, Boeing patented the multi-beams laser-cutting and was among the pioneering companies cutting titanium with a laser. (Bensoussan, 2016, October 5).

Figure 11. Three-dimensional laser cutting (3D fiber laser machine Rapido Prima Power).

In 1979, the Italian company Prima Industrie has invented the first 3D laser cutting process (History Prima Power). Now, this technology is widely used when cutting cavities and holes with a complex contour in various volumetric parts and structural units using advanced laser cutting machines (Figure 11) (3D fiber laser machine Rapido Prima Power).

One of the major contributions from Japan resulted from developments at Amada in 1985 that led to a "Clean Cut" finish that produced a non-oxidized cut in 3mm stainless steel on a system shipped in 1986 (Belforte, 2010, January 1). Subsequently TRUMPF developed inert gas (fusion) cutting with its RF-excited CO_2 laser in Germany later in that decade. These processes and others opened the door for high-quality metal cutting, without secondary operations, a major industry advance.

The use of laser cutting at the present stage.

For more than 50 years after the appearance of the first commercial laser cutting machines, technical and technological development in this segment has moved along the path of a slow evolutionary increase in the radiation power of all known types of industrial lasers and, as a result, an equally smooth increase in the speed and productivity of the equipment. The quality, accuracy, service, "friendliness" of the software interface, and the thickness of the workpieces to be processed grew smoothly.

In the last decade, the development of practical applications of laser cutting has accelerated significantly. This was mainly determined by the industrial development and the appearance of new types of high-power diode-pumped lasers with incomparably higher power density, reliability, service life, and efficiency in the market. One of the signs of the current stage of development is that the undisputed leaders of the 1990s in the field of mass cutting of sheet material – CO_2 lasers – have been ubiquitously replaced by powerful fiber-optics and disk lasers in recent years, which have captured more than 70% of the segment of precision cutting of metals with a thickness up to 20 mm over the past few years. Another feature of the modern development of laser cutting technologies is associated with the creation of industrial models of pulsed lasers with nano-, pico-, and femtosecond duration of radiation pulses.

Conclusions.

1. The modern laser technology market continues to develop actively, as evidenced by the steady growth in sales since the early 1980s. This indicates that the demand for laser technology is inextricably linked with the development of high technology production and scientific-technological progress.

2. The progress of industrial laser technology is expressed in reaching the first places in sales of fiber-optics and disk lasers, actively displacing CO_2 lasers, as well as in an increase in the share of diode lasers, including for pumping fiber-optics, disk, and Nd:YAG lasers.

3. Recently, the trends in the use of laser technology have changed, in particular, their industrial and medical applications are decreasing, while there is an increase in their use in the fields of sensor production and communication.

4. Due to the emergence and development of laser engineering and technologies, it was possible to bring the aerospace industry (for example, by modernizing the design of turbine blades), high-precision mechanics (for example, drilling jewel bearings, laser-based correction of the accuracy of clockwork), liaison and communication (for example, creation of fiber optic communication) to a qualitatively new level, to create unique cutting technologies (for example, medical stents), and much more.

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Conflicts of Interest.

The authors declare no conflict of interest.

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Історія створення лазерів і аналіз впливу їх застосування при обробці матеріалів на розвиток певних галузей промисловості

Анотація. *Стаття присвячена аналізу історії створення лазера, як одного з найбільш значущих технічних винаходів 20 століття. Ця стаття присвячена встановленню зв'язку між періодизацією етапів винаходу та впровадження окремих видів лазерів, з їх впливом на створення окремих видів техніки і промислових технологій обробки матеріалів, розвитком певних галузей економіки та науково-технічного прогресу в цілому. При підготовці статті використовувалися загальноприйняті методи, які широко використовуються*

при підготовці історичних дослідницьких робіт: історичний метод, – для вивчення та інтерпретації текстів першоджерел і пошуку інших доказів, які використовуються для дослідження, а також викладу історичних подій пов'язаних з розвитком лазерної техніки; історико-генетичний метод, – для вивчення генезису конкретних історичних явищ і аналізу причинності змін у розвитку лазерної техніки; історико-критичний метод, для відображення причинно-наслідкових зв'язків, відтворення подій, що вплинули на розвиток лазерної техніки; метод історичної періодизації. Різноманіття різних можливих варіантів застосування лазерів позбавило змоги розмістити всі зібрані матеріали в рамках однієї статті і тому автори вирішили зупинитися на фактах, які на їх думку є найбільш цікавими, значущими, слабовивченими і маловідомими. У статті розглянуті етапи: винаходу першого лазера; створення перших комерційних лазерів; розробки перших застосувань лазерів в промислових технологіях обробки матеріалів. Окремо приділено увагу «патентним війнам», які супроводжували різні етапи створення лазерів. Проведено порівняльний аналіз розвитку ринку лазерної техніки від етапу створення до сучасності. Показано, що сучасний ринок лазерної техніки продовжує активно розвиватися, про що говорить стабільне зростання продажів лазерів, що триває останні 10 років. Це свідчить про те, що попит на лазерну техніку нерозривно пов'язаний з розвитком наукоємного виробництва і науково-технічним прогресом. Проведений аналіз показав, що в останній час змінилися тенденції використання лазерної техніки, зокрема відбувається скорочення їх промислового і медичного застосування, при цьому спостерігається зростання їх застосування в областях виробництва сенсорів і комунікації.

Ключові слова: *лазер; історія лазерів; Теодор Майман; Національний Музей Американської Історії; ринок лазерів; застосування лазерів*

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История создания лазеров и анализ влияния их применения при обработке материалов на развитие определенных отраслей промышленности

Аннотация. *Статья посвящена анализу истории создания лазера, как одного из величайших технических изобретений 20 века. Настоящая статья посвящена установлению связи между периодизацией этапов создания и*

внедрения отдельных видов лазеров, с их влиянием на изобретение отдельных видов техники и промышленных технологий обработки материалов, развитием определенных отраслей экономики и научно-технического прогресса в целом. При подготовке статьи применялись общепринятые методы, широко используемые при подготовке исторических исследовательских работ: исторический метод, - для изучения и интерпретации текстов первоисточников и поиска иных доказательств, используемых для исследования, а также изложения исторических событий связанных с развитием лазерной техники; историко-генетический метод, - для изучения генезиса конкретных исторических явлений и анализ причинности изменений в развитии лазерной техники; историко-критический метод, для отображения причинно-следственных связей, воссоздания событий повлиявших на развитие лазерной техники; метод исторической периодизации. Многообразие различных возможных вариантов применения лазеров не позволило разместить все собранные материалы в рамках одной статьи и поэтому авторы решили остановиться на фактах, которые по их мнению являются наиболее интересными, значимыми, слабоизученными и малоизвестными. В статье рассмотрены этапы: изобретения первого лазера; создания первых коммерческих лазеров; разработки первых применений лазеров в промышленных технологиях обработки материалов. Отдельно уделено внимание «патентным войнам», которые сопровождали разные этапы создания лазеров. Проведен сравнительный анализ развития рынка лазерной техники от этапа создания до современности. Показано, что современный рынок лазерной техники продолжает активно развиваться, о чем говорит продолжающийся стабильный рост продаж лазеров за последние 10 лет. Это свидетельствует о том, что спрос на лазерную технику неразрывно связан с развитием наукоемкого производства и научно-техническим прогрессом. Проведенный анализ показал, что в последнее время изменились тенденции использования лазерной техники, в частности происходит сокращение их промышленного и медицинского применения, при этом наблюдается рост их применения в областях производства сенсоров и коммуникации.

Ключевые слова: *лазер; история лазеров; Теодор Майман; Национальный Музей Американской Истории; рынок лазеров; применения лазеров*

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Representatives of the sugar industry of the Russian Empire at the World's Fair in Paris in 1900

Abstract. *Nineteenth-century world exhibitions were platforms to demonstrate technical and technological changes that witnessed the modernization and industrialization of the world. World exhibitions have contributed to the promotion of new inventions and the popularization of already known, as well as the emergence of art objects of world importance. One of the most important world events at the turn of the century was the 1900 World's Fair in Paris. Participation in the World's Fair was not the first experience of this kind of activity for sugar growers in the Russian Empire. Most of them were members of the Kyiv branch of the Russian Technical Society, which in turn took the most active part in the work of blighty and international industrial exhibitions, receiving high awards. The main sugar enterprises were concentrated on the territory of modern Ukraine in the possession of several large companies owned by Tereshchenko, Kharitonenko, Khanenko, Brodskyi, Simirenko, Yakhnenko and others. The Russian sugar industry occupied a prominent place at the World's Fair in Paris in 1900, as its share in world sugar production was 17%, and the area of beet crops, it was ahead of all other countries (in 1900 sugar beets were sown 548,796 hectares). The exposition testified to this powerful development of the industry. At the World's Fair in 1900, Russia's sugar industry was housed in the Palace of Agriculture and was represented in the pavilions by well-known sugar firms, such as the Department of Land (Timashiv Beet Sugar and Refinery), I. H. Kharitonenko and his son; brothers Lazar and Lev Izrailevich Brodskyi; O. N. Tereshchenko, heirs of F. A. Tereshchenko; the Tereshchenko brothers, the Botkin brothers (Novo-Tavolzhanskyi sugar factory); joint-stock companies of sugar and refineries: “Constance”, “Germanov”, “Gmina Lyshowiche”; E. A. Balasheva (Mariinskyi Sugar Plant of Kyiv Province), H. H. Balakhovski (Mariinskyi beet-sugar and refineries of the Kursk province). A characteristic feature of the sugar industry was that they mainly represented family businesses based on strong family ties, ethno-cultural and religious values. In addition, they intertwined the functions of owners and managers. Thus, the author tries to analyze the participation of representatives of the sugar industry in the World's Fair in 1900 and define the role of exhibitions as*

indicators of economic development, to show the importance and influence of private entrepreneurs, especially from Ukraine, on the sugar industry and international contacts.

Keywords: *World exhibition; sugar industry; economic cooperation; private entrepreneurs*

Introduction.

The sugar industry of the Russian Empire was one of the leading branches of agriculture, the level of development of which largely determined the economy of the state as a whole in the mid-19th – early 20th century. The relevance of the study is determined by the importance of the appearance of world exhibitions as platforms for demonstrating technical and technological changes that have become evidence of the modernization and industrialization of the world. World exhibitions have contributed to the promotion of new inventions and the popularization of already known, as well as the emergence of art objects of world importance.

In addition, world exhibitions are the historical context in which we can assess the economic condition of the country. With the development of capitalism, especially after the reforms of 1860–1870's in Russia, the nature of the organization, scale and specialization of exhibitions were begun to change. Their role and significance has increased. Economic, scientific and technical societies and unions became more and more often organizers of industrial exhibitions, which testified to the growth of new tendencies in society. Entrepreneurs from all over the Russian Empire actively participated in such events and tried to demonstrate their achievements in various fields of science, technology, agriculture, railway construction and the sugar industry in particular. World exhibitions of the early twentieth century served to develop international trade, strengthen and expand economic cooperation between states. Exhibiting innovations in various fields of science, technology and production was of great cognitive importance for many areas of human activity. The rate of economic growth in Russia in the active phase of capitalist industrialization at the turn of the 19th and 20th centuries was comparable to the rate of growth of the leading countries of the Western world at that time.

It was a market economy integrated into the world economy. Undoubtedly, the economic potential of tsarist Russia was concentrated in the agricultural sector. The sugar industry is a branch of the food industry that specializes in the production of white granulated sugar from sugar beets or sugar cane. Also, the sugar industry includes enterprises for the production of refined sugar from granulated sugar. In 1914, Russia ranked 2nd in the world for the production of beet sugar (after Germany). Of the 241 sugar factories then operating in the Russian Empire, 203 were located in modern Ukraine. The main enterprises were concentrated in the ownership of several large companies owned by Tereshchenko, Kharitonenko, Khanenko and Brodskyi.

Research methods.

Analysis of publications on the problem shows the existence of different areas of its study. Investigation concerning the architecture of exhibition complexes by B. Kuperstein (Kupershtejn, 1899a), (Kupershtejn, 1899b), E. Zeidler (Tsaidler, 1988) should be noted. The history of Russia's participation in world exhibitions is covered by V. Kokorev and I. Inozemtseva. Some data on the formation of the agricultural market, the sugar industry, the penetration of foreign capital into Ukraine, are contained in the works of S. L. Ronin (Ronin, 1926), K. H. Voblyi (Voblij, 1928).

Among the researchers who study the history of pre – Soviet sugar refining entrepreneurship in Ukraine and consider some aspects of this problem, we should mention V. Olyanich (Olyanich, 2000), T. Lazanska (Lazanska, 1996), Yu. Belikov (Bielikov, 2003), M. Moskaliuk (Moskaliuk, 2008). The works of P. Vinokurov (Vinokurov, 2001), M. Lachaeva (Lachaeva, 1991), N. Ovchinnikova (Ovchinnikova,1990), E. Rakov (Rakov, 2000) are devoted to Russia’s participation in the World Exhibition in Paris in 1900. Publications by O. Benoit (Benua, 1900a; Benua, 1900b), P. Ge (Ge, 1900), S. Diaghilev (Diagilev, 1900) are devoted to artistic life at the Paris Exhibition of 1900. In Polish historiography, the research topic is covered in the monograph of Eleonora Jedlinska (Jedlińska, 2015).

The author dedicated her work to one of the most important world exhibitions of the late nineteenth century. According to E. Edlin, the exhibition of the nineteenth century is a kind of phenomenon of European civilization, and was used mainly to demonstrate the achievements of science and its application in industry. An important element of world exhibitions were works of art, considered by the author as an expression of the synthesis of matter and spirit of modern times.

The main content of her monograph is artistic issues, which is accompanied by historical, sociological, political and philosophical problems that shape the social attitudes of the late XIX century. Large fragments relate to the presence of Polish artists at the 1900 World's Fair – their work and role in shaping the consciousness of Poland's existence.

The publications of A. Basirov (Basyrov, 1985) and D. Kogan (Kogan, 1964), I. Shudryk (Shudryk, 2003) and D. Hryhoriev (Grigorev, 2003) are devoted to the activities of the artist Konstantin Korovin, his participation in the design of Russian pavilions at the Paris Exhibition in 1900. O. Gaidai (Gaidai, 2013) wrote directly about the participation of the Kharitonenko trading house in the World Exhibition in Paris. The activity of sugar magnates of merchant origin and their influence on the economic development of Ukraine became the subject of O. Donik's (Donik, 2006) research. T. Vodotyka wrote about outstanding Ukrainian entrepreneurs of the new generation who made themselves (Vodotyka, 2019). An interesting group of sources is represented by the reports of various committees and persons sent to the exhibition (Ministerstvo finansov, 1901, 117), (Shvarts, 1900). Another group of works of the pre-revolutionary period is intelligence on the history of the sugar industry. The vast majority of such publications contain economic and statistical analysis of the development of the sugar

industry of the Russian Empire in the late nineteenth – early twentieth century. First of all, these are the works of L. Brokl (Brokl, 1885), L. Volokhov (Volokhov, 1913), M. Tsekhanovsky (Tsekhanovskii, 1904; Tsekhanovskii, 1911), Y. Janson (Ianson, 1869). The technical intellectuals was an advanced detachment of Russian scientific thought. In the mid-1960s, it founded the Russian Technical Society, an organization that, from its founding in 1866 until 1917, not only engaged in research in industry, applied science, and technology, but also concentrated the cultural initiative in its hands (educational initiatives). 9 branches of this society, which operated in Ukraine, namely in Kyiv, Mykolayiv, Odesa, Kharkiv, Katerynoslav, Sevastopol, Zhytomyr, Kremenchuk and Poltava, made a significant contribution to the development of educational and exhibition work. The most effective of them were Kyiv (Otchet o dvadtsatipyatiletney deyatelnosti Kievskogo otdeleniya Imperatorskogo russkogo tehnicheskogo obschestva (1871–1896), 1896), Odessa (Otchet o deyatelnosti Odesskogo otdeleniya Imperatorskogo russkogo tehnicheskogo obschestva za 1895 g., 1896), Kharkiv (Otchet o deyatelnosti Harkovskogo otdeleniya Imperatorskogo russkogo tehnicheskogo obschestva za 1880–1881 g., 1881) and Mykolayiv(Otchet o deyatelnosti Nikolaevskogo otdeleniya Imperatorskogo russkogo tehnicheskogo obschestva za 1898 g.,1899) branches. O. Pylypchuk wrote a monograph on the contribution of the Kyiv branch of the Russian Technical Society to the development of the sugar industry in 2019 (Pylypchuk, 2019).

Information about the life and work of prominent figures of various branches of the society can be found in obituaries written by the head of the Kyiv branch M. Bunge in memory of L. Brodskyi (Bunge, 1904, p. 567) and N. Tereshchenko (Bunge, 1903, p. 18). O. Donik (Donik, 2001) dedicated his dissertation to the activities of the Tereshchenko family. A thorough article by Arthur Chandler, published in World's Fair, Volume VII, Number 3, in 1987 (Chandler, 1987), is devoted to the activities of the World's Fair in Paris in 1900.

The purpose of this article is to analyze the participation of representatives of the sugar industry of the Russian Empire in the World Exhibition of 1900 and to determine the role of exhibitions as indicators of the achievements of economic development of society. It is necessary to show the importance and influence of private entrepreneurs, especially from Ukraine, on the development of the sugar industry and the establishment of international contacts.

The research is based on the fundamental principles of scientific knowledge of objectivity and historicism. The principle of objectivity obliges to consider historical phenomena and events in all their complexity, versatility and contradiction. The historical approach places the object of our study in the context of certain socio-political and economic conditions. Important in the process of working on the topic was the observance of the dialectical principle, which requires considering the phenomena in the relationship and interdependence. The principle of historicism involves the analysis of historical facts in a particular historical environment, in the dynamics. Adherence to these principles is necessary, given that the theme of business,

exhibition activities today has not only scientific but also socio-cultural and economic significance.

The study is based on universal general scientific methods – analytical, synthetic, logical and special historical methods. The structure of the work is due to the problem-chronological approach, which made it possible to study the entrepreneurial activity of sugar producers in the historical dynamics. The chronological method helped to penetrate deeper into the essence of the problem and consider it in chronological order of historical facts. Of particular importance in this article is the comparative-historical (comparative) method, which involves the analysis of events and facts, which are determined in terms of common and different between them, which becomes the basis for further interpretations, considerations, explanations and conclusions. After all, in the process of comparison there is an opportunity for a new, deeper and unbiased view of the issue. The comparison allows us to show the degree of effectiveness of management and organizational actions aimed at creating conditions for exhibition activities.

The structural-system method is necessary because it provides a view of exhibition activity as a complex system with various socio-economic ties. This method helped to clarify the nature and features of the interactions of government structures on business.

The method of social psychology allowed to determine which elements of consciousness played a major role in the formation of socio-psychological phenomena inherent in individual entrepreneurs, which played a major role in the development of the sugar industry. Each study of a problem is based on the general theory of scientific knowledge, as well as on specific methodological tools.

Ukrainian and foreign historical science are in search of new conceptual guidelines and approaches that could be used to recreate the multidimensional history of mankind. Modern historians A. Bolebrukh, J. Kalakura, S. Kulchytskyi, O. Reyent, V. Smolii, and others work fruitfully in this direction.

Leading for this article is a multidisciplinary (interdisciplinary) approach, which is reflected in the conceptual apparatus.

The conceptual apparatus of the work is characterized by the use of terms and categories of both traditional historical and borrowed from other related sciences.

Results and discussions.

For sugar growers in the Russian Empire, participation in the World's Fair was not the first experience of this kind of activity.

Most of them were members of the Kyiv branch of the Russian Technical Society, which in turn took the most active part in the work of blighty and international industrial exhibitions, receiving high awards. For example, in 1873 at the Vienna World's Fair for a specific collection of items typical of the sugar industry presented by the Kyiv branch of the Russian Technical Society, including a model of the diffuse apparatus of the member of the Volyn Beet and Sugar Plant Friedrich Henrikhovich

(Gavrilovich) Annie system and a model for Oleksii Bobrynskyi – The international jury of the exhibition awarded the Kyiv branch a bronze medal with a diploma.

In the same year, 1873, members of the society presented sugar products at the Third London Annual International Exhibition. In particular, on behalf of the Queen of Great Britain, the sugar in the tiles was awarded a special medal, presented at the exhibition and first obtained by the method of the director of the Smilyanskyi refinery – engineer-technologist and inventor Mykola Cherykovskyi. It was the only enterprise in the Russian Empire that produced such a product. The Smilyanski Sugar Plant, which belonged to Counts Bobrynskyi, was a model of scientific and technological progress at that time. Smilyanskyi and Balakliivskyi plants became the basis for the development of the sugar industry in Ukraine and a practical school of sugar production for the factories of the Russian Empire (Yelesina, 2012, XXXII, p. 135).

In addition, two more Gold medals were awarded to exhibits presented by the Yakhnenko-Simirenko firm, organized by the brothers Terentii, Kondrat and Stepan Mykhailovych Yakhnenko and Vasyl Fedorovych Simirenko. In 1849, "Kievskie gubernskie vedomosti" noted: "In terms of the perfection of building construction, excellent instruments and apparatus used here, the size of spacious premises and production, the Yakhnenko and Simirenko plant not only ranks first among the beet sugar and refinery plants in Russia, but has few rivals even abroad". In July 1876, in Philadelphia, the International Industrial and Art Exhibition was held, timed to coincide with the 100th anniversary of the United States, in which almost all European countries took part. Samples of sugar from 9 Ukrainian factories were exhibited from the Russian Empire, presented by a separate group "Collection of the Kyiv branch of the Russian Technical Society". The examination recognized all sugar samples as products of the highest grade and presented them to the awards of the 1st and 2nd classes, and the Exhibition Commission awarded the Kyiv branch of the Russian Technical Society a large Gold Medal. In 1878, at the Paris World Exhibition, the sugar industry of the Russian Empire was represented by more than ten sugar factories of Ukraine (Kaganov, 2016).

Unfortunately, to date, there are no comprehensive, thorough works on the study of the participation of representatives of the sugar industry of the Russian Empire in the 1900 World's Fair in Paris.

The World's Fair is a historic event, a chance for each country to demonstrate its achievements in a variety of fields and an opportunity to improve its trade, cultural and political reputation in the world. World exhibitions are a kind of tool used by governments for dialogue with the public, demonstration of the achievements of national industry, the use of the latest technologies. From another point of view, according to Arthur Chandler the 1900 exhibition demonstrated in every respect the feeling that profit and entertainment should come first in the minds of all participants. In a sense, this is a return to the late medieval spirit of the annual fair, where saints are honored and decorum, but the motive for profit worried the minds more than the main task that gave rise to the event. However, this does not mean that the authors or

exhibitors have lost faith in progress or become cynical about the prospects for achieving "the greatest good for the greatest number of people" (Chandler, 1987).

Historian Richard Mandell, in his book "Paris 1900: The Great World's Fair", wrote:

> *...As much as France saw its power and fame slip away in other areas, there was one cultural manifestation in which French supremacy was not contested – the organization of multipurpose exhibitions. For the French by this time, the thought of exhibitions evoked emotions surprisingly similar to those that evoked the thought of the French colonial empire. In the face of political embarrassment, humiliation in diplomacy, and economic stagnation, the exposition and empire made up for another defeat to some extent. Although it is unlikely that the creation of a republic by itself (the empire was promoted by free-planting adventurers, expositions of autonomous bureaucrats) simultaneously showed (or seemed to be in this important aspect) a dynamic, resourceful French republic for the whole world (Mandell, 1967, p. 30).*

The World's Fair in Paris opened on April 14, although many pavilions had not been completed and equipped yet. It lasted until November 12, 1900. Russia was an exception: the opening of its branch took place on April 17. Due to the special relations of France with Russia, the government was the first to allocate the largest area for the Russian exposition – 24 thousand square meters (Rakov, 2000). The symbol of the exhibition was the meeting of the new century. To participate in it, the empire spent 5,226,895 rubles (of which the government allocated 2,226,895 rubles, and institutions and exhibitors another 3 million rubles). The commission for the preparation of the Russian department was headed by the director of the Department of Trade and Manufactures V. Kovalevskyi. V. Tenishev was appointed General Commissioner of the Russian department, and R. Meltzer was appointed chief architect (Ovchinnikova, 1990, p. 27). The main pavilion was built in the medieval Russian style, with many towers, tent roofs, jagged walls, patterned windows, reminiscent of the Moscow Kremlin. The exhibition focused on the ethnography of the so-called suburbs – Siberia, the Far North, Central Asia, the Caucasus. Several halls and an exposition in the Palace of Civil Engineering were dedicated to the construction of the Great Siberian Way, the Russian oil industry, and a rubber manufacturing company (Zdaniya i sooruzheniya Vsemirnoy vyistavki v Parizhe 1900 g., 1899).

The Russian sugar industry occupied a prominent place at the World's Fair in Paris in 1900, as its share in world sugar production was 17%, and the area of beet crops, it was ahead of all other countries (in 1900 sugar beets were sown 548,796 hectares). The exposition testified to this powerful development of the industry (Otzyiv "Journal des Fabricants de Sucre" o nashey saharnoy promyishlennosti na Parizhskoy vsemirnoy vyistavke, 1900, 1–39, p. 1034).

Special exhibitions such as the Sugar Industry Exhibition had two main objectives. The first one was to acquaint visitors with the history of the sugar industry, the technique and technology for processing beets into sugar, with the final product

intended for consumption. And the second task was to acquaint specialists with the latest machines, technical improvements and devices. And if the first task was easy enough to implement at exhibitions, then with the second, certain problems arose. First of all, it was the reluctance of factories supplying new machines for sugar processing to exhibit them at world exhibitions, since progress in mechanical engineering was visible only in the way of work, and it was impossible to show it at the exhibition. Therefore, the exhibitions mainly demonstrated equipment and devices related to scientific and chemical research, chemical and technical control of production, and the fight against pests of sugar beet. There was no direct benefit to the owners of sugar factories from exhibitions. Sugar, as an item of trade, which has the same composition and appearance, cannot be subject to competition on external grounds, as in other areas of industry. Sugar markets at the end of the 19th century were already defined, and it was not realistic to find new buyers through exhibitions. Therefore, many sugar refineries did not see the point in serious participation in world exhibitions. The sugar department at the 1900 Paris World's Fair confirmed this position (Vestnik saharnoy promyishlennosti, 1900, p. 753). Among the countries participating in the exhibition, the most successful was the exposition of the Society of Austrian Sugar Makers. In a small pavilion, the Sugar Industrial Museum of the Czech Polytechnic exhibited models of 39 shells and apparatus used in sugar production and developed mainly by Czechs. A collection of different types of sugar and a collection of production waste were presented. On live specimens, diseases of the beet tops and roots were demonstrated. As a result of scientific research, changes in sucrose under the influence of high temperatures, all kinds of chemical compounds of sugar, a collection of bacteria developing on beetroot were presented. In addition, there were presented bagasse, fodder for oxen and horses, made from peat and molasses, from bagasse and molasses, a systematic collection of molasses de-sugar products. For chemists, the latest instruments used in laboratories at sugar factories were exhibited, such as the Strohmer revolving polarimetric device with 18 polarimetric tubes, the Strohmer beet respiration monitor, the newest Fritsch polarimeter with glass rocks (Vestnik saharnoy promyshlennosti, 1900, p. 754). There was no collective exhibition in the Russian department. At the World Exhibition, the Russian sugar industry was housed in the Palace of Agriculture and was represented in the pavilions by well-known sugar firms, such as the Administration of Lots (Timashevskyi Beet Sugar and Refinery), I. H. Kharitonenko with his son; brothers Lazar and Lev Izrailevich Brodskyi; O. N. Tereshchenko, the heirs of F. A. Tereshchenko; brothers Tereshchenko, brothers Botkin (Novo-Tavolzhansk sugar plant); joint stock companies of sugar beet and refinery factories: “Constance”, “Hermanov”, “Lyszkowice”; E. A. Balasheva (Mariinski sugar factory, Kyiv province) H. H. Balakhovski (Maryinskyi sugar beet and refinery of Kursk province) (Sliaskii, 1900, p. 755). The government of the Russian Empire sought to collect as many original exhibits as possible, therefore, for the exhibitors, it approved a number of benefits: free provision of premises at the exhibition, acceptance, at the expense of the treasury, costs of shipping exhibits, their

insurance, arrangement and finishing of the Russian department. Another characteristic feature of the representatives of the sugar industry was that they mainly represented family enterprises based on strong family ties, ethno-cultural and religious common values. In addition, they intertwined the functions of owners and managers. The success of the family business was determined by the ability to accept and use foreign experience, the willingness to cooperate with representatives of different national and religious groups. The World's Fair provided such an opportunity. It was only necessary to use it wisely.

The largest exposition was at the Trading House "I. H. Kharitonenko and his son", whose products were of high quality. Its enterprises actively implemented the latest achievements in the field of sugar beet production. At the family's sugar factories there were quite powerful experimental fields at that time (Zhukov, 1898). P. Kharitonenko attracted talented engineers and designers to work at his sugar enterprises, which had a positive effect on production. Kharitonenko's sugar warehouses were not only in many cities of the Russian Empire (Sumy, Moscow, St. Petersburg, Kharkiv, Tomsk, Vladivostok, Novosibirsk), but also in France, Scotland, and Persia (Derzhavnyi arkhiv Sumskoi oblasti, f. 235, op. 1, spr. 93).

P. Kharitonenko's showcases were designed by the famous architect F. Shekhtel (Berton, 1991, p.265). At one time he designed the neo-Gothic mansion of S. Morozov, the house of Ryabushynskyi (now the museum-apartment of O. Gorkyi), the house of Derozhynska (now the Australian Embassy in Moscow) and the mansion of P. Kharitonenko in Moscow (now the residence of the British ambassador) (Berton, 1991, p. 15). On fairly spacious scaffolding were installed on three sides of oak cabinets, distinguished by elegant carvings. On the fourth side was an entrance protected by two lions made of wood. In the middle was a table on which are albums with photographs of factories and outbuildings. In addition, awards of previous exhibitions, portraits of Ivan Herasimovych and Pavel Ivanovych Kharitonenko, photos of the main savings, horse breeding, cattle breeding, a group of employees led by the owner. The cabinets housed the massecuite (a thick, viscous mass formed after evaporation from sugar syrup water, which consists of sugar crystals and intercrystalline liquid, containing 92–93% dry matter), sugar I crystallization and yellow II crystallization, refined main and sawn. According to the list of items intended for the World's Fair in Paris in 1900, refined sugar was prepared in pieces, tiles, in ordinary wrappers, mixed and thin 5 poods of each type; split in height and width – 3 poods. Samples of sugar and yellow sand were taken from 8 plants in the usual form for sale (3 poods each). In addition, samples of bread, corn and beet seeds (4 varieties) produced on the estates were placed in the showcases. Bread in grain was presented in a variety of varieties, 2 varieties of winter wheat, spring, rye, oats, barley, millet (Derzhavnyi arkhiv Sumskoi oblasti, f. 235, op. 1, spr. 57).

Brochures were compiled especially for the exhibition, from which visitors could learn basic information about the participants. In particular, it was reported that the Trading House "I.H. Kharitonenko with his son" owned in Kharkiv, Kursk, Chernihiv

and Poltava provinces own arable land and meadows (35, 535 acres), leased land (17,193 acres), forests (10,842 acres), a total of 63,570 acres of land (Sliaskii, 1900, p. 755). In addition, the Trading House owned 1 sugar refinery and 7 sand and sugar factories (one leased). Among them were the Pavlovsk refinery in Sumy and sand and sugar factories: Natalivskyi, Parkhomovskyi, Yankovo-Rogskyi, Ugroyedskyi, Chervono-Yaruzskyi, Rzhavskyi and Parafievskyi. They processed beets produced mainly on their own estates. For sowing beets, 11,700 tithes and 2,000 tithes were leased annually, and the average beet harvest was 1.4 million and 1.75 thousand berkivtsi. Beet processing and annual sugar production were expressed in the following figures: Pavlovsk refinery produced up to 2.2 million poods of refined, and sand and sugar factories processed about 1.575 million beets and produced 2.065 million poods of crystalline sand, using 1758 horsepower and 3124 workers. The average sugar yield was 52.5 pounds (Sliaskii, 1900, p. 756). It should be noted that all factories had schools for the children of workers, hospitals, pharmacies and free medical care for both sick workers and the local population. In addition to the factory hospitals, the Kharitonenko family also maintained a 30-bed central hospital in Sumy.

The exhibition of sugar factories and factories of N. A. Tereshchenko and the heirs of F. A. Tereshchenko was placed in cupboards around the stage. The jars exhibited: white sugar I crystallization, yellow sugar II crystallization, massecuite, molasses with an indication of chemical analysis, several copies of beetroot and cutting samples. Chemical engineer, Mr. Kohlen, gave explanations to the visitors of the Tereshchenko pavilion. The average annual production of sugar at their factories was 2,257,772 poods, with 1,698,166 berkovts of beet processed. N. A. Tereshchenko owned Tetkinskyi, Andrushevskyi, Staro-Osotyanskyi sugar factories. The heirs of F. A. Tereshchenko owned the Chervonskyi, Korovinetskyi, Martynovskyi sugar factories. The partnership of the Tereshchenko brothers owned the Voronezh and Krupetskyi factories (Vestnik saharnoy promyshlennosti, 1900, p. 757). The estates Andrushevskoe, Golovkovskoe, Volfinskoe and Manukhovskoe, owned by N. A. Tereshchenko, consisted of 23,619 tithes of arable land and 13,788 dessiatines of forests. Every year, 417,000 berkovts were collected on N.A. Tereshchenko's own plantations. Tula and Mykhailovskyi refineries exhibited head refined, sawn and chopped, refined massecuite. Numerous photographs were exhibited depicting factories, schools, hospitals, outbuildings. The average annual processing of sugar at these factories was 900 poods at Tula, 800 pounds at Mykhailovskyi (Vestnik saharnoy promyshlennosti, 1900, p. 757).

The estates of the heirs of F. A. Tereshchenko: Chervonske, Korovinetske, Martynovske, Hlushetske, Privitovske, Miastkovske and Olshanske had a total of 58,857 dessiatines of land. Of these, the arable land was 33,199 dessiatines, and the forestry 18,171 dessiatines. An average of 490,000 berkovites were collected from these lands. In total, the amount of arable land and forests of the Tereshchenko family reached 101,639 dessiatines with an annual beet production on their own plantations of 907,000 berkovts (Vestnik saharnoy promyishlennosti, 1900, p. 758).

The pavilion of brothers Lazar and Lev Izrailevich Brodskyi was presented in the Russian style with high towers. In cabinets with glass walls on all sides, jars with samples of massecuite I, II, III crystallization, white sugar I crystallization, yellow sugar II crystallization and molasses were exhibited. In addition, refineries presented samples intended for processing, crystalline sand, syrups, sawn and crushed refined sugar of various sizes. All items on display were accompanied by chemical analysis. A large number of photographs told about the internal structure of factories, factory and economic structures, schools and hospitals. The Brodskyi's issued a brochure that could serve as a model for the exhibitors, in which they reported that they owned 16 sugar factories. Of these, 3 are sand refineries and 13 are sugar refineries (Vestnik saharnoy promyshlennosti, 1900, p. 789). The average annual productivity of three refineries in Odessa (2,500,000), Lebedinskyi (1,000,000) and Koryukovskyi (1,500,000) was 5,000,000 poods of sugar. The equivalent value of 5,000,000 poods of refined sugar was 27,500,000 rubles (Vestnik saharnoy promyshlennosti, 1900, p. 790). The Brodskyis owned 34,796 tithe of their own land, including 17,842 tithes of forests and 31,615 tithes of leased land. The area of their own and leased land for sowing beets was 30,900 tithes. The wages of workers and employees of the plant a year amounted to 1,517,490 rubles. The excellent technical equipment of the plant and the efficient management allowed Brodskyi to reduce the cost of producing one pound of sugar. Its cost was: for technical expenses – 50.05 kopecks, for management costs 20.37 kopecks, a total of 70.02 kopecks. The cost of producing one pound of refined sugar was 41.25 kopecks. At the Brodsky factories there were 10 savings banks with a capital of 226,000 rubles, 16 hospitals for 160 beds with pharmacies and constant medical care, 2 two-grade schools for 400 children, 2 one-class schools for 200 children. In addition, there were 10 libraries, 2 reading rooms, 2 own orchestras of workers and artisans, 4 cheap teahouses and 20 barracks for 8000 workers (Vestnik saharnoy promyshlennosti, 1900, p. 791).

Kharytonenky, Tereshchenky and Brodskyis represented the world's largest sugar-processing firms. The owners of these firms were called sugar kings. Later, less significant firms were presented at the exhibition and, accordingly, their showcases were more modest.

A fairly systematic collection of sugar products was exhibited in the window of the Mariinskyi sugar factory, which was located in the Kyiv province, in the Moshno-Horodishchenskyi estate of E. A. Balasheva. Visitors were exposed to: beet cutting, diffusion juice, massecuite I and II crystallization, white sugar I crystallization and yellow II crystallization, samples of lime, molasses, separation waste sugar, beet seeds. An informational description of the estate was attached to the display case. It indicated that the estate occupies 43,481 tithes, of which 20,640 tithes of land, and 22,841 tithes of forests. The farm was operated on 20 farms, of which 12 were beet farms. Own beets were grown on an area of 1,700 acres of land. The plant had a savings and loan, a two-year school, a 12-bed hospital and a meteorological station. The description showed graphical data on production. The next in the exposition was a cabinet with products

produced by the Maryinskyi sugar beet and refinery of the Kursk province owned by H. H. Balakhovskyi. He presented several samples of head and sawn refined sugar, white sugar of I crystallization and samples of beets. How the plant worked, how it was equipped, one could learn from the collection of photographs of the sand and refinery departments. No explanatory note was provided on the size of the production.

Novo-Tavolzhanskyi beet sugar plant, which belonged to the Botkin brothers, placed its exposition on the table. There were presented two small barrels with sugar of I crystallization, samples of beet seeds and breads produced in the estates.

At the World Exhibition in Paris, joint stock companies of sugar beet and refineries were presented. These were "Constance" (Warsaw province, Kutnovskyi district, commune Kutno, village Constance. Joint-stock company of Kutnovskyi sugar-beet refinery. Steam engines were used, the number of workers was 561 people), “Hermanov” (Joint-stock company of beet-sugar and refinery plant, Sokhachevskyi county, commune and the village of Szymanow (Spisok fabrik i zavodov Rossiyskoy Imperii. 1912 g., 1912, p. 136). Steam engines were used, the number of forces was 450, the number of workers was 652 people) and “Lyszkowice” (Joint-stock company of Lovici district, commune and village of Lyszkowice. Steam engines were used number of forces 258, number of workers 392 people), which jointly exhibited a collection of refined sugar samples. In the Russian sugar department, the well-known machine-building plant “Borman, Shvede and Co” was presented, which exhibited an apparatus for boiling refined sugar (Spisok fabrik i zavodov Rossijskoj Imperii, 1912, p. 134–136).

The Department of Districts placed the products of the Timashevsk sugar beet plant on Trocadero Square, in the Kremlin, next to other industrial products. Everything at this exposition was thought out to the smallest detail. Numerous statistical and graphic tables showed production data, photographs made it possible to see the technical equipment of factories, houses and hospitals. Detailed brochures have been compiled to guide the display. Timashevsk plant displayed samples of beets, massecuite, white sugar I crystallization, yellow II crystallization, heads of refined sugar of various sizes. From the description, visitors to the exhibition could learn that the Timashevsk sugar beet and refinery was located in the Samara province. It owes its origin to the English company “Johnson Montgomery Woker & Co”, which first introduced the sugar beet culture in the Samara province. The daily processing of beets at the plant was 1500 berkovts. The plant processed beets exclusively from the plantations of specific estates, calculated for it according to the sugar content of the beets. The refining department processed granulated sugar, which was purchased from other factories and produced about 650,000 poods of refined sugar per year. There was a hospital at the plant, medical assistance was provided, there was a school for 130 workers' children and a meteorological station. A distinctive feature of the sand and refinery was the presence of electric motors driven by turbines, which were located on the Kineli River, at a distance of 300 fathoms from the plant.

The French "Journal des Fabricants de Sucre" published a review of the participation of the Russian sugar industry in the Paris World's Fair. The article noted that the Russian sugar industry had developed quite rapidly over the past ten years. However, the author noted that the intensive means of production, typical of France, Germany, Belgium, and the Netherlands, were rarely used in Russian farms, as a result, their yields were extremely low. As an example, the following figures were given: 1899–1900 in Germany, 399 plants produced 1.791 million tons of sugar with 428,142 hectares of crops, that is, an average of 1,073 hectares per plant. In Russia, at the same time, 269 plants produced, for 510,568 hectares of crops (that is, an average of 1,892 hectares per plant), only 925 thousand tons of sugar. On the other hand, from 1 hectare of crops in Germany received 4180 kg of sugar, and in Russia only 1813 kg. Thus, the author came to the conclusion that Russia was dominated by extensive farming. In terms of sugar consumption, Russia also occupied a rather modest place among other countries, which was due to the high tax on sugar and, consequently, its high cost. Thus, the consumption of sugar in 1898–1899 in Russia was about 5.86 kg per person, while in Sweden or Norway – 15.76; The Netherlands – 13.13; Germany – 14 kg (Otzyiv "Journal des Fabricants de Sucre" o nashey saharnoy promyshlennosti na Parizhskoy vsemirnoy vystavke, 1900, 1–39). Although in the early twentieth century, Russia was forced to sell surplus sugar production abroad.

In addition, the author of the article in the "Journal des Fabricants de Sucre" drew attention to the exhibits of the Trading House "I. H. Kharitonenko with his son", the companies of the brothers Lazar and Lev Brodski, the Society of the Tereshchenko Brothers, noting that all the high awards they received deservedly won. However, the greatest reward during the World's Fair for P. Kharitonenko was the news that the definition of the Department of Heraldry of the Government Senate of October 26, 1900, his wife, daughters Elena, Natalia and son Ivan recognized in the hereditary nobility, with the right to enter the first part of the noble genealogical book (P. Kharitonenko himself was raised in the hereditary Russian Empire Noble Dignity on April 18, 1899, for particularly useful activities in the field of blighty industry) (Derzhavnyi arkhiv Sumskoi oblasti, f. P-2362, op. 1, spr. 4.)

The World Paris Exhibition of 1900 demonstrated not only the success of sugar production in the Russian Empire, but also the fruitful work of industrialists and entrepreneurs. During the exhibition, the Russian exposition received 1,589 awards: 212 higher, 370 gold medals, 436 silver, 347 bronze and 224 honorary awards (Tsvetkov, 2018).

By the end of the exhibition, France could congratulate itself on the most successful exhibition ever organized. While the attendance figures fell short of expectations – 60 million visitors was the figure expected by the panelists – the results (51 million) made it by far the highest attendance of any exhibition. More than 83,000 exhibitors took part in the exhibition, more than 42,790 prizes of various degrees were awarded. The 127 congresses brought together over 80,000 participants and renewed Paris' reputation as a meeting place for the world. Paris showed the world that the city

was at the forefront of technological innovation. Yet for all the statistical triumphs, the 1900 exhibition marked the end of an era. The industrial exhibitions, architecture, and art of 1900 symbolized a summary of the nineteenth century rather than an omen of the twentieth, except that technology promised to be a major force in the entertainment industry.

Conclusion.

Turning to the history of participation in the World's Fair, which had become a colossal common cause, a real manifestation of a public initiative that brought together thousands of people from different walks of life, is important in both historical and practical contexts. An exhibition or international fair is a platform where a country can share its achievements with the rest of the world. At the beginning of globalization, these events were organized in the form of pavilions from different countries of the world, providing information about their citizens and culture. It was also popular to present new inventions from all over the world at the exhibitions.

However, such events were sometimes held for propaganda purposes, since politics and money were of great importance in this area.

A comprehensive study of the participation of sugar producers in the Russian Empire in the exhibition business of the early twentieth century will help not only to analyze their contribution to improving the quality of industrial development, to characterize the interaction of industrial cultures of Russia, Western Europe and the world, but also to consider it as part of the Russian Empire as part of the modernization process. Becoming one of the recognized leaders of the world community in the sugar industry, sugar growers at the World's Fair in Paris in 1900 significantly contributed to strengthening the prestige of the Russian Empire abroad. The exhibition gave a powerful impetus to the further spread of the industrial revolution and the development of advanced industries in the sugar industry.

Thus, the experience of exhibition activities at the turn of the XIX–XX centuries can be taken into account in terms of studying the development of the global economy and culture. To date, the world has accumulated vast experience in organizing and conducting exhibition and fair activities. The Exhibition today enables a particular enterprise to carry out simultaneously communicative, pricing, sales and product policies. An appeal to the history of the preparation and holding of exhibitions in the pre-reform period, and especially in the post-reform period, when they became a colossal common cause, a real manifestation of public initiative, bringing together hundreds and thousands of people from different social strata, is useful both in historical and practical terms.

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The author declare no conflict of interest.

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Представники цукрової промисловості Російської імперії на Всесвітній виставці у Парижі 1900 року

Анотація. *Всесвітні виставки дев'ятнадцятого століття були майданчиками для демонстрації технічних і технологічних змін, що стали свідченням модернізації та індустріалізації світу. Всесвітні виставки сприяли просуванню нових винаходів і популяризації вже відомих, а також появі арт-об'єктів світового значення. Однією з найважливіших світових подій на рубежі століть стала Всесвітня Виставка в Парижі 1900 року. Для цукрозаводчиків Російської імперії участь у Всесвітній виставці не була першим досвідом такого виду діяльності. Більшість з них були членами Київського відділення Російського технічного товариства, яке в свою чергу брало найактивнішу участь у роботі вітчизняних та міжнародних промислових виставок, отримуючи на них високі нагороди. Основні цукрові підприємства були сконцентровані на території сучасної України у володіннях кількох великих компаній, що належали Терещенкам, Харитоненкам, Ханенкам, Бродським, Симиренкам, Яхненкам та іншим. Російська цукрова промисловість займала помітне місце на Всесвітній виставці в Парижі 1900 р., адже її участь у світовому виробництві цукру складала 17%, а за площею бурякових посівів вона випереджала всі інші країни*

(на 1900 р. цукровими буряками було засіяно 548796 га). Експозиція засвідчила цей потужний розвиток галузі промисловості. На Всесвітній виставці 1900 року цукрова промисловість Росії розміщувалася в Палаці землеробства і була представлена в павільйонах відомими цукровими фірмами, такими як Управління уділів (Тимашівський бурякоцукровий і рафінадний завод), І. Г. Харитоненко з сином; брати Лазар і Лев Ізраїлевичі Бродські; Н. А. Терещенко, спадкоємці Ф. А. Терещенко; брати Терещенки, брати Боткіни (Ново-Таволжанський цукровий завод); акціонерні товариства цукрових і рафінадних заводів: "Константція", "Германов", "Гміна Лишковіце"; Е. А. Балашева (Маріїнський цукровий завод Київської губернії), Г. Г. Балаховський (Мар'їнський буряково-цукровий і рафінадний заводи Курської губернії). Характерною особливістю представників цукрової промисловості було те, що вони в основному представляли фамільні підприємства, засновані на міцних родинних зв'язках, етнокультурних і релігійних спільних цінностях. Крім того в них переплiталися функції власників і управлінців. Таким чином авторка в статті зробить спробу проаналізувати участь представників цукрової галузі у Всесвітній виставці 1900 р. та визначити роль виставок як показників досягнень економічного розвитку суспільства, показати значення та вплив приватних підприємців, особливо з України, на розвиток цукрової промисловості та встановлення міжнародних контактів.

Ключові слова: *всесвітня виставка; цукрова промисловість; сільське господарство; економічне співробітництво; приватні підприємці*

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Представители сахарной промышленности Российской империи на Всемирной выставке в Париже 1900 года

Аннотация. *Всемирные выставки девятнадцатого века были площадками для демонстрации технических и технологических изменений, стали свидетельством модернизации и индустриализации мира. Всемирные выставки способствовали продвижению новых изобретений и популяризации уже известных, а также появлению арт-объектов мирового значения. Одним из важнейших мировых событий на рубеже веков стала Всемирная Выставка в Париже 1900 года. Для сахарозаводчиков Российской империи участие во Всемирной выставке не было первым опытом такого вида деятельности. Большинство из них были членами Киевского отделения Русского технического общества, которое в свою очередь принимало активное участие в работе отечественных и международных промышленных выставок, получая на них высокие награды. Основные сахарные предприятия были сконцентрированы на территории современной Украины во владении нескольких крупных компаний,*

принадлежавших Терещенко, Харитоненко, Ханенко, Бродским, Симиренко, Яхненко и другим. Российская сахарная промышленность занимала заметное место на Всемирной выставке в Париже в 1900 г., ведь ее участие в мировом производстве сахара составляла 17%, а по площади свекловичных посевов она опережала все остальные страны (в 1900 сахарной свеклой было засеяно 548 796 га). Экспозиция подтвердила такое мощное развитие этой отрасли промышленности. На Всемирной выставке 1900 года експозиция сахарной промышленности России размещалась во Дворце земледелия и была представлена в павильонах известными сахарными фирмами, такими как Управление уделов (Тимашевский свеклосахарный и рафинадный завод), И. Г. Харитоненко с сыном; брать Лазарь и Лев Израилевичи Бродские; Н. А. Терещенко, наследники Ф. А. Терещенко; братья Терещенко, братья Боткины (Ново-Таволжанский сахарный завод); акционерные общества свеклосахарных и рафинадных заводов: "Константция", "Германов", "Лышковице"; Е. А. Балашева (Мариинский сахарный завод Киевской губернии) Г. Г. Балаховский (Марьинский свекольно-сахарный и рафинадный заводы Курской губернии). Характерной особенностью представителей сахарной промышленности было то, что они в основном представляли фамильные предприятия, основанные на прочных родственных связях, этнокультурных и религиозных общих ценностях. Кроме того, в них переплетались функции владельцев и управленцев. Таким образом автор в статье попытается проанализировать участие представителей сахарной отрасли во Всемирной выставке 1900 года и определить роль выставок как показателей достижений экономического развития общества, показать значение и влияние частных предпринимателей, особенно из Украины, на развитие сахарной промышленности и установления международных контактов.

Ключевые слова: *Всемирная выставка; сахарная промышленность; сельское хозяйство; экономическое сотрудничество; частные предприниматели*

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Contribution of Professor K. G. Schindler (1869–1940) in formation of agricultural mechanics, theory and practice of testing of the agricultural machines and tools in Ukraine

Abstract. *The article highlights the life and creative path of the outstanding domestic scientist, theorist, methodologist and practitioner of agricultural engineering K. G. Schindler, associated with the formation of agricultural mechanics in Ukraine. The methodological foundation of the research is the principles of historicism, scientific nature and objectivity in reproducing the phenomena of the past based on the complex use of general scientific, special, interdisciplinary methods. For the first time a number of documents from Russian and Ukrainian archives, which reflect some facts of the professional biography of the scientist, were introduced into scientific circulation. The main directions of fruitful pedagogical and scientific activities of K. G. Schindler, key segments of his creative search, which determined the further development of agricultural engineering, his leadership in the scientific community were described. It was proved that Professor K. G. Schindler has the primacy in founding the Station of Testing for Agricultural Machines and Tools at the Kiev Polytechnic Institute, which provided students of agronomic and mechanical faculties with the opportunity to get acquainted with the existing types and designs of tillage machines, systematically test its research methods. In addition, the station carried out scientific work on the study of certain issues of agricultural mechanization, development of methods and devices for research of agricultural machinery and implements. The seven functions of the agronomic-type research station developed by scientists for the first time in Europe at the beginning of the last century have become a reference point for many generations of researchers of agricultural machinery. K. G. Schindler was the first in the world to theoretically substantiate the need to improve the design of tillage equipment depending on soil and climatic conditions, made a significant contribution to the theory of soil deformation with the shelf of the plow body. In addition, he improved the Sakka dynamometer, developed a control dynamometer to check traction dynamometers and other devices, improved existing*

and developed new designs of tillage machines. K. G. Schindler was the first in Ukraine to teach a course in agricultural engineering.

***Keywords**: K. G. Schindler; agricultural industry; research station of agricultural machines and implements; Kiev Polytechnic Institute*

Introduction.

One of the basic directions of the modern history of agricultural science in Ukraine is the study of the intellectual biographies of its prominent representatives, which express domestic priorities in the modern information space, contribute to the formation of ideas about the integral process of organizing agricultural research and the dissemination of industry education. The study of their creative heritage will help to revive the national idea in Ukraine, to ensure the unity and continuity of generations of agricultural scientists. Considering this, agricultural biography should become the fundamental segment of research on the history of domestic agricultural science. The development of this direction is especially important in conditions when the biography of the humanities is becoming more active, the scientists of which have suffered more from political actions than the researchers of natural disciplines.

At the same time, a new surge in the development of biography studies and the reconstruction of biographies of agricultural scientists is associated with a rethinking of previous historical knowledge, a shift in research emphasis from the "history of elites" to "second plan" personalities, a turn to historical anthropology, micro-level research, and an appeal to interdisciplinary methods in the study biographical information. A striking figure in the history of agricultural science in Ukraine is Professor K. G. Schindler – a talented scientist in the field of agricultural mechanics, teacher and organizer of the educational process. Generating approaches laid down by K. G. Schindler have not lost its relevance and are a roadmap for posterity.

The purpose of this work is to reconstruct the contribution of Professor K. G. Schindler in the formation of agricultural mechanics, theory and practice of testing the agricultural machines and tools, to show his role in the organization of higher branch education in Ukraine.

Research methods.

The methodological basis of the research is formed by the principles of historicism, scientific nature and objectivity in converging the phenomena of the past based on the complex use of general scientific, special, interdisciplinary methods. The general scientific methods such as synthesis, analysis, induction and deduction were used to determine the object and subject, goals and objectives, scientific novelty of the article, formulation of conclusions and generalizations. The article uses a modern categorical-conceptual apparatus applied by historians, biographers and specialists in other branches of science, taking into account the interdisciplinary nature of this research. The complex application of various means of search, analysis and synthesis

provided the possibility of optimal use of archival documents and materials, published sources, scientific works.

Results and discussion.

The special role of K. G. Schindler in the development of domestic mechanical engineering was noted in a number of publications by his contemporaries, colleagues and students. First of all, it should be noted the publication of A. Beretti about the article by the scientist on American threshers (Beretti, 1898). The articles of M. M. Kagan, V. I. Nagibin, S. N. Bogoiavlensky about the Station for Testing of Agricultural Machines and Tools at the KPI (Kagan, 1902; Nagibin, 1909; Bogoiavlensky, 1913). After the emigration of K. G. Schindler in 1919, the situation with regard to the results of his work changed radically and moved, at best, into the format of statements of some facts of his biography and activities. In the early 1920's, the compilers of a joint collection dedicated to the 25th anniversary of the Kiev Polytechnic and Kiev Agricultural Institutes (Kiev Polytechnic and Kiev Agricultural Institute, 1923) first spoke about the role of K. G. Schindler in creating the Station of Testing for Agricultural Machines and Tools at the KPI, as well as the Cathedra of Mechanical Engineering created by him, where a new scientific school was born; in a stated form, his pedagogical activity is revealed, and especially as the Dean of the Mechanical and Agricultural departments of the Kiev Polytechnic Institute of Emperor Alexander II. In the future, all references to K. G. Schindler pass into the fragmentariness of practically the same direction.

Some information about the life and work of K. G. Schindler is reconstructed in publications on the Russian emigration by S. Narizhnyi, Z. Sladek, L. Ye. Kovalevsky (Narizhnyi, 1942; Sladek, 1991; Kovalevsky, 1991). In the essay on history, prepared for the 100th anniversary of the KPI, its authors named K. G. Schindler in the galaxy of "... outstanding scientists ..." who, together with E. F. Votchal and P. R. Slezkin taught at the agronomic department, as well as with V. L. Kirpichev, S. P. Timoshenko, E. O. Paton, G. G. Metz, S. P. Sheinterg, etc. formed his own scientific school "...agricultural engineering" and it became "... leading in training for agricultural engineering" (Bieliakov, et al., 1995, 20-21).

Academicians of the Russian Agricultural Academy and the Ukrainian Academy of Agricultural Sciences P. M. Vasilenko and L.V. Poghorily have addressed some achievements in the field of agricultural engineering of this famous scientist (Vasylenko & Voitiuk, 1998; Poghorily, Mudruk & Shkvyra, 2003). A number of publications about K. G. Schindler have prepared by the author of this article (Verhunov, 2019; Verhunov, Mudruk, 2001; Verhunov, Mudruk, & Shkvyra, 2019). However, all the listed works do not give a complete picture of the scientist's personality and only fragmentarily coverage certain aspects of his life and work.

K. G. Schindler occupies an honorable place in domestic and world agricultural science. Despite the high assessment given by Academician V. I. Vernadsky in 1911, an ordinary professor of the KPI of Emperor Alexander II K. G. Schindler, as an

outstanding scientist and teacher, other luminaries regarding his creative research, first of all, in the field of testing agricultural machines and tools (Vernadsky, 2002, p. 197), fundamental discoveries in the field of plow construction, and historians regarding the organization of educational process in the KPI, as well as inventions presented at all kinds of competitions, however, due to the solely ascertaining of individual facts of the biography, numerous inconsistencies continue to remain and even the pages of his good deeds that have not been fully investigated in the name of the further development of domestic and world science.

Two editions, prepared on the basis of materials from Ukrainian and Russian archives, to some extent reveal in some detail some of them, especially regarding the stay and work of K. G. Schindler during the period of emigration (1919–1940) (Verhunov & Mudruk, 2001, p. 6; Verhunov, Mudruk, & Shkvyra, 2019, p. 12–15). The new documents that became available not so long ago made it possible to reveal more contextually the activities of K. G. Schindler during his work at the KPI of Emperor Alexander III and especially fill the years of stay in KPI with theoretical, methodological and practical meaning in the field of testing agricultural machines and tools. The same applies to expanding the understanding of his creative activity to create new types of plows, seeders and other agricultural implements.

Thanks to familiarization with previously unavailable archival documents, unknown facts about the biography of the scientist were revealed. He was born on June 15, 1869, in Tver in a family of Swiss citizens – Gabriel Schindler and Emilia Müller, who had a residence permit in the Russian Empire (SA Tver region. F. 848. D. 1. C. 228. P. 25). In 1887, he graduated from the additional class of the Tver real school, receiving secondary education. Demonstrating a penchant for the exact sciences, from September 1 of the year he entered the Mechanical Engineering Department of the Imperial Moscow Technical School (SAK. F. 18. D. 2. C. 289. P. 102). After completing a full course of study, in 1893, he was awarded the title of mechanical engineer, as well as personal honorary citizenship, provided for in paragraph 2 of § 23 of the "Charter" of the school. During studies, he first got acquainted with the competition for testing agricultural tools, held on September 12, 1892 at the educational and practical Butyrsk farm of the Agricultural School of the Imperial Moscow Society of Agriculture, already then noted the absence of specially trained specialists for expert assessment of the economic suitability of agricultural machines and tools in some soil and climatic conditions of the country (Perepelkin, 1896, p. 11).

K. G. Schindler began a career as a mechanic at the Borinsk sugar plant of brothers S. and N. Gardenin, located near Lipetsk, Tambov province, where he worked until 1895. In the same year he went to Germany, Austria, Switzerland for study the agricultural machines and tools. For some time he performed private work on the installation of equipment at the factories of the Central Industrial Region, in the summer of 1896 he taught and supervised practical classes for students on the study of agricultural machines at the Moscow Agricultural Institute, where K. G. Schindler got to know the future Honorary Academician of the USSR Academy of Sciences

V. P. Goriachkin (1868–1935). Together with him, he organized the Second Competition-Exhibition of Agricultural Machines from July 10 to August 12, 1896 under the auspices of the Imperial Moscow Society of Agriculture at Butyrsk Farm.

K. G. Schindler prepared two fundamental "Reports" for the sections of the exhibition: 1) reapers and reapers-binder; 2) complex threshers and locomotives (Perepelkin, 1897, pp. 6–89). The level of professionally prepared reports testified to the emergence of a talented specialist in this field. In his opening remarks, K. G. Schindler and V.I. Grinevetsky first proposed to organize the special stations for the theoretical and practical study of agricultural machines and implements (Kagan, 1902, p. 8). They proved the need for state transfer of agricultural engineering issues to the specialized scientific institutes.

As one of the best specialists in the field of agricultural machinery, the Ministry of Agriculture and State Property sent K. G. Schindler to Germany, France, England and North America to study industrial mechanical engineering. In Paris, he got acquainted with the activities of the Station for Testing Machines and Tools headed by Professor Ringelmann. The scientist displayed the results of what he saw in the United States in a series of articles on the pages of the magazine "Boss" published in 1897–1898. These publications not only brought him well-deserved fame and authority, but also became the impetus for the beginning of a professional discussion among specialists. An example was the presentation of K. G. Schindler features grain storage at American elevators (Beretti, 1898, p. 1184). In the end, the discussion contributed to the introduction of the American approach in the Russian Empire.

In 1897, K. G. Schindler published an original brochure with 48 figures in the text – "From Practice for Practice. Agricultural tools and machines. I. Plow", which was recognized as a helpful manual for both farmers and students of agricultural educational institutions of the Ministry of Agriculture and State Property (Bibliografiya, 1898, p. 388). According to the proposal of the Governor of the Kharkov Educational District of September 25, 1898 No. 79042, K. G. Schindler was appointed a lecturer for the hire of the Kharkov Technology Institute of Emperor Alexander III (KhTI), which opened in July 1885, with the instruction to lead the drawing lessons in one of the first-year groups for six annual hours with a reward for each annual hour of 120 rubles (SAK. F. 18. D. 2. C. 289. P. 71).

There are several reasons for K. G. Schindler's move to Kharkov. In the first place was the government's decision to start systematic training of specialists for agricultural engineering. To this end, on the basis of the recommendation of the ministers of public education and finance, KhTI was proposed to open an appropriate cathedra, as well as a Station for Testing of Agricultural Machines and Tools. At a meeting of the Scientific Committee of the KhTI on May 14, 1895, this recommendation was unanimously supported (SA Kharkov region. F. R-1682. D. 2. C. 370. pp. 13–16). The new cathedra was headed by Adjunct Professor G.A. Latyshev (1857–1922), who also performed the duties of equipping a Station for Testing of Agricultural Machines and Tools similar to a station at the University of Halle (Germany) (SA Kharkov region. F. R-1682. D. 2.

C. 370. P. 134). After moving to Kharkov, K. G. Schindler and G. A. Latyshev took an active part in an attempt to reorganize the educational process at the institute.

K. G. Schindler in the presence of the director and the clerk of the institute signed the "Sworn List", in which he made an oath to serve faithfully and obey His Imperial Majesty in everything (SA Kharkov region. F. R-1682. D. 2. C. 370. P. 3). A little later, on October 8, 1898, a new proposal was received from the trustee of the Kharkov Educational District under No. 7444 – to work as a laboratory assistant created in 1895 at the KhTI and in fact the first in the Russian Empire specialized station for testing agricultural machines and tools with retaining the right to conduct drawing classes for first year students (SAK. F. 18. R-1682. D. 2. C. 289. P. 71).

By letter No. 91 of December 19, 1898, classified as "secret", the director of the KhTI turned to the Moscow chief police officer with a request to provide information about "... police reliability ... of mechanical engineer K. G. Schindler". Already on December 25, 1898, he allowed K. Schindler to be a teacher at the Kharkov Technology Institute of Emperor Alexander III (SA Kharkov region. F. R-1682. D. 2. C. 370. P. 10). In turn, the director of the institute notified "His Excellency Mr. Trustee of the Kharkov Educational District "About receiving a document on the reliability of K. G. Schindler". At that time, obtaining such a document was more important than the professional qualities of the applicant for the position. In his letter of consent, the chief police officer asserted that K. G. Schindler, while living in Moscow, had "... approving behavior and moral qualities, he was not involved in political matters" (SA Kharkov region. F. R-1682. D. 2. C. 370. P. 15). Almost immediately, K. G. Schindler became involved in all the components of the organization of the scientific and educational process at the institute. He was appointed a temporary member of the economic committee for summer time instead of Professor Gemilian, who was on leave (SA Kharkov region. F. R-1682. D. 2. C. 370. P. 27). In fact, he was considered at the institute as deputy members of the economic committee during their vacations.

K. G. Schindler was invited to participate in competitions for testing agricultural machines and tools produced, first of all, in the European part of the Russian Empire. So, according to the petition of the Kursk Provincial Zemstvo Board of June 28, 1899, which followed the recommendation of Professor G.A. Latyshev, K. G. Schindler was invited to take part in the corresponding competition on August 25–31 in Kursk and September 15–17, 1899, in Korochi, Kursk province. The zemstvo asked K. G. Schindler to prepare general characteristics of the known tools before the start of the competition, as well as to inform what devices were needed for expert assessment, including the Burg's dynomometer. The director of the KhTI asked the Trustee of the Kharkov Educational District to send K. G. Schindler to these competitions, as a result of which he received consent and an advance payment of 75 rubles "... from the amounts to strengthen the funds of the Kharkov Technology Institute" (SA Kharkov region. F. R-1682. D. 2. C. 370. pp. 28, 29).

At that time, the director of the KhTI – a well-known scientist in the field of mechanics and strength of materials, Professor V. L. Kirpichev (1845–1913) drew

attention to a young, gifted, hardworking employee. After his appointment in 1898 as director of the newly established Kiev Polytechnic Institute of Emperor Alexander II, he, by letter dated May 16, 1899, invited K. G. Schindler to the position of Extraordinary Professor of the Cathedra of Applied Mechanics (SAK. F. 18. D. 2. C. 289. P. 103). It was agreed that K. G. Schindler, starting from September 1, 1899, would officially teach mechanics at the agricultural department and a special course in agricultural engineering at the Mechanical Department (SAK. F. 18. D. 2. C. 289. P. 18). Nevertheless, the process of official admission to the KPI, unfortunately, was delayed for various reasons. There was a possibility that K. G. Schindler would take the position of acting Extraordinary Professor in the Cathedra of Mechanics at the Warsaw Polytechnic Institute of Emperor Nicholas II (SAK. F. 18. D. 2. C. 289. P. 14), as evidenced by a letter dated November 3, 1899, from the Vice-Director of the Department of Trade and Manufactures of the Ministry of Finance to the director of this institute. K. G. Schindler became a full-fledged full-time teacher only from December 31, 1899, according to the transferring and permission of "... His Excellency Mr. Minister of Finance" (SAK. F. 18. D. 2. C. 289. P. 72), but not beginning of 1900, as D. Zhurilo writes in monograph (Zhurilo, 2016, p. 88).

There is reason to assert that the choice of Kiev for the implementation of creative plans for K. G. Schindler was no accident. As it was possible to establish, the stories and letters of his cousin, R.F. Schindler, who completed a full course of sciences at the Faculty of Medicine of the Imperial University of St. Vladimir and from December 16, 1881, was approved as a Doctor with honors, served as a positive perception of this possibility (SAK. F. 16. D. 465. C. 4761. P. 168). However, the main argument in favor of Kiev and its polytechnic institute was, of course, a personal Professor V. L. Kirpichev's invitation for K. G. Schindler with the prospects of conducting research in the field of testing of the agricultural machines and tools (SAK. F. 18. D. 2. C. 289. P. 103). Before starting teaching at KPI, with the permission of the Minister of Finance, he went on an overseas leave to Germany for a month to inspect the factories of the agricultural machines (SAK. F. 16. D. 465. C. 4761. P. 71).

At a joint meeting of the agricultural and chemical faculties on March 18, 1900, K. G. Schindler substantiated the need to open a Station for the Testing of Agricultural Machines and Tools at the KPI (Kramarenko, 1924, p. 188; Nagibin, 1909, pp. 38–53). Director of the institute K.A. Zvorykin, recommending K. G. Schindler for the position of acting Dean of the Agricultural Department, wrote that he not only possesses "... excellent lecturer qualities ...", but also outstanding "... organizational and administrative skills" (SAK. F. 18. D. 2. C. 289. P. 30). These qualities, in his opinion, K. G. Schindler demonstrated by creating a machine testing station at the KPI, without adequate budgetary funding. Thanks to the researches of the scientist, it was possible to prove "... a great importance of the mechanical tillage, contributing to both a more perfect way of using existing soil constituents, and saving moisture, depending on its type and condition" (SAK. F. 18. D. 2. C. 289. P. 31).

By constantly experimenting, the station made it possible to expand the design possibilities of using agricultural machines and tools obtained under strict scientific conditions. In addition to considering exclusively the technical side of the issue, K. G. Schindler structurally filled the Station for Testing Agricultural Machines and Tools of the KPI, which he was creating, not only with a special laboratory, but also with an experimental field. The scientist argued that in the study of agricultural machines and tools, as much attention as possible should be paid to the final result of all agricultural operations, namely, the level of the yield of cultivated plants. In addition, the station provided an opportunity for students of the agronomic and mechanical faculties of the KPI to get acquainted with the existing types and designs of agricultural machines and tools directly in operation, as well as study the methods of its research. Besides, scientific work was carried out on the study of some issues of agricultural mechanization, as well as the development of techniques and instruments for testing of the agricultural machines.

Among the devices which almost until the end of the 30s of 20th century used in the country when testing agricultural implements should, in the first place, put the redesigned K. G. Schindler traction Sakka dynamometer. There was a serious flaw in its primary design, namely the absence of a device giving a zero line on the diagram and the use of a simple wooden pencil, reinforced with a clamping screw. As a consequence, the control measurements gave a significant error in the measurement values. Practically from the first days of its activity, the Kiev Station of Testing for Agricultural Machines and Tools faced this shortcoming. As a consequence, K. G. Schindler developed and proposed some design improvements. The wooden drum was replaced with an aluminum one, in which two spring plates were fixed. Instead of millimeter steel, use specially lined and cut paper into separate sheets. A small sharp-toothed roller was adapted to draw a constant line, which was pressed by a spiral spring. They started using a specially designed metal pencil. In addition, they completely abandoned the hinges, redesigning the dynamometer by replacing the conical buffer spring with a cylindrical one. Moreover, another type of self-recording dynamometers '... with a flat spring" was made. By the way, all dynamometers designed by K. G. Schindler were manufactured by the KPI Mechanical Workshop, whose products in 1903 '... at the exhibition of professional schools ... from the organizing committee took second place after the Imperial Moscow Technical School.' On the basis of about 5000 annual measurement diagrams obtained, the corresponding measurement procedures for both new structures based on the Sakka dynamometer were developed, and two basic principles of their use were proposed: stress gets tired and deformed; 2) conclusions with the existing theory of agricultural machines and implements should be based on a large number of repeated observations or on mass experiments. As a consequence, K. G. Schindler proposed a method for dynamometric accounting when plowing simultaneously with measuring the width and depth of the furrow. According to it, the assessment was carried out on eight furrows (4 in one and the other direction). However, the general conclusion was taken for six furrows. As for

the self-regulating device redesigned by K. G. Schindler, for a long time in the Russian Empire he was considered a control (reference) and all institutions that had traction dynamometers annually sent them to the Station for testing agricultural machines and tools of the KPI for verification. Among them is the Imperial Agricultural Museum in St. Petersburg, where "... a dynamometer for horse drives designed by Prof. K. G. Schindler ... "was used for... inspection of plow dumps and their correction' (Bogoiavlensky, 1913, pp. 290–292).

K. G. Schindler was directly related to the opening of the Station for Testing of Agricultural Machines and Tools of the Elisavetgrad Agricultural Society in 1907. He developed principles and an estimate, chose the location of the station and the director-learner – V. I. Nagibin. All the proposals were accepted by the society during K. G. Schindler's visit to Elisavetgrad on February 10–13, 1907 (SAK. F. 18. D. 2. C. 289. P. 52). Subsequently, on its basis, according to the decision of the Kherson provincial zemstvo of April 20, 1911, the famous Ajam Experimental Station was created, headed by M. I. Irlikov (now the Institute of Agriculture of the Steppe of NAAS). A little later, in 1912, the Yakimovsk Test Station was opened under the leadership of D. D. Artsybashev, and then – in Orel, Samara, Tashkent, Blagoveshchensk, Vyatka and at the Plotyansk Experimental Station.

K. G. Schindler was one of the first in Europe to develop the seven functions of the agronomic-type test station, which have been a reference point for many generations of agricultural technicians (Verhunov, & Mudruk, 2001, p. 21; The tasks, 1907, p. 6). Today, only the number of tests have changed, and the equipment has become more energy-intensive, automated and using a space navigation system. However, the generating approaches laid down by K. G. Schindler have not lost its relevance. In accordance with its, only in Ukraine, Leonid Poghorily's Ukrainian Research Institute for Forecasting and Testing of Equipment and Technologies for Agricultural Production, Cathedra of Mechanization of Tillage and Sowing of Agricultural Crops of the NSC "Institute of Mechanization and Electrification of NAAS", Academician P. M. Vasilenko's Department of Agricultural Machines and Systems Engineering of Faculty of Mechanics and Technology of National University of Life and Environmental Sciences of Ukraine are functioning.

The first in world practice, the scientist prepared and published in 1902 a fundamental work – the atlas of agricultural machines "Polytypes, sketches and drawings of machines-tools of modern agriculture" in the series "The doctrine of agricultural machines and tools" (Polytypes, 1902). In 1904, based on the "Atlas", K. G. Schindler publishes no less, as they say, the requested special monographs: "Machinery-tools of modern agriculture" (The machines – implements, 1904) and "Theory and design of arable tools" (Schindler, 1904). These publications revealed the evolution of the design and manufacturing technology of plows, and K. G. Schindler established himself as an outstanding historian of science and technology.

The competitions for testing agricultural machines and tools brought K. G. Schindler deserved fame as a leading specialist in his field in the country and the

world. The first official of these was the competition for testing sugar beet seeders (from six manufacturing plants) held in the summer of 1902 in the "Sukhoi Yar" estate of the Countess M. E. Branitska's countryseat near Bila Tserkva. The initiator of the event was the Kiev Society for Mutual Assistance of Farmers and Foresters with Higher and Secondary Education, in which K. G. Schindler was one of ten honorary members. He became the developer of the "Test Program" published prior to the competition. After this competition, dozens of similar ones took place. Suffice it to recall: 1) the test of self-feeders for steam threshers in the Zhukovsk economy of Prince V. S. Kochubei in the Poltava region in July 1904; 2) in the estate "Pady" V. L. Naryshkina (Saratov province) in the summer of 1905; 3) in the Sharov economy of L. Ye. Kening (Kharkov province) in September 10–22, 1905; 4) in the economy "Sukhoi Yar" in the estate of Countess M. E. Branitska near Bila Tserkva – beet cutters in May 24, 1907; 5) in the spring of 1908, organized by the Elisavetgrad Society of Agriculture – plows and seeders; 6) testing of combined seeders under the auspices of the Kiev Mutual Aid Society of Farmers and Foresters with Higher and Secondary Education in the summer of 1908; 7) threshers under the auspices of the Ekaterinoslav Provincial Zemstvo on June 3, 1908; 8) plows, organized by the Benderov District Zemstvo Council (Bessarabian province) on May 26, 1909; 9) agricultural machines and implements on the Freidenberg estate, organized by the Finnish Central Agricultural Society on August 25, 1909; 10) tools for surface tillage, the organizer of the competition of which was the Poltava Provincial Zemstvo on June 25–26, 1910, and others. And these are only those for which, under the editorship of K. G. Schindler, large-circulation available official "Reports" were published. There is documentary evidence the competitions were held in other regions of the Russian Empire, for example, in the Caucasus and Crimea (SAK. F. 18. D. 2. C. 289. P. 60).

On November 14, 1905, in the main physical auditorium of the Kiev Polytechnic Institute, K. G. Schindler, after six years of promises, publicly defended his dissertation presented at the Mechanical Department entitled "Theory and design of arable tools" for the title of Adjunct Professor of the Institute (SAK. F. 18. D. 2. C. 289. P. 40). The level of the prepared dissertation, the depth of the results examined in questions of theory and methodology, as well as the brilliant defense almost immediately brought K. G. Schindler into the ranks of the leading scientists in the field of applied mechanics not only in the country, but also in the world. After successfully defending his dissertation, by orders of the Minister of Trade and Industry of December 13, 1905, K. G. Schindler was appointed an Extraordinary Professor in the Cathedra of Mechanics, and on January 19, 1907, an Ordinary Professor in the same cathedra. The desire to be approved as an Ordinary Professor in the Cathedra of Mechanics of the KPI prompted him on May 4, 1906 to officially resign from the post of Dean of the Agricultural Department (SAK. F. 18. D. 2. C. 289. P. 71, 49).

Since 1907 K. G. Schindler was among the first 14 members of the Bureau of Agricultural Mechanics of the Scientific Committee of the Main Directorate of Land Management and Agriculture, created by the Tsar's Decree in 1894 (Erk, 2004, pp. 40–

41). The scientist took part in almost all official events organized by the Bureau in the capital, as well as machine competitions throughout the country: Yekaterinoslavl, Bezenchuk, Vitebsk, Odessa, held in 1910–1911. During its visit, he prepared expert opinions and assessments. K. G. Schindler received an invitation to become a member of the editorial board of the well-known 12-volume edition "Complete Encyclopedia of Russian Agriculture and Related Sciences". He not only reviewed, but also wrote articles for it, for example "Steam Plows" to Volume VI (Schindler, 1912). He was among the members of the editorial committee of the agricultural and economic journal of the South Russian Society for the Promotion of Agriculture and Agricultural Industry, better known as the Kiev Agricultural Syndicate – "Economy" (1906).

The outstanding authority of K. G. Schindler in the professional environment of scientists and teachers is evidenced by the fact of his election as Chairman of the Board of a specialized creative branch scientific association – the Kiev Agronomic Society, which the author of this publication considers as one of the forerunners of the modern National Academy of Agrarian Sciences of Ukraine. The date of its formation should be considered February 12, 1909, when the Kiev City Administration approved the "Statute". Already on February 17, 1909, the first general meeting of 39 founders took place, at which the election was held under the comrade (deputy) of the Chairman of the Management Board – S.L. Frankfurt (Iost, Skuratov & Skvortsov, 1910, p. 9). K. G. Schindler held this position until March 1911.

In 1911, K. G. Schindler, as the Dean of the Mechanical Department, together with seven leading professors and three teachers, by "... order of His Excellency Mr. Minister of Trade and Industry ..." (SAK. F. 18. D. 2. C. 289. P. 66), was relieved of his post at the KPI for political reasons: for defending the rights of students in the well-known case of Kasso on violation of the restrictive 5% rule and admitting an additional twenty Jewish students to the institute (Los', Plygunov, & Chernenko, 1961). As for the Station for Testing of Agricultural Machines and Tools at the KPI, after K. G. Schindler's dismissal, it practically lost its significance and, most importantly, its authority. The same fate befell the cathedra headed by him. The authority of the scientist was evidenced by the fact that even after his release from official posts, he was invited to participate in the All-Russian conference on the organization and tasks of stations in relation to agricultural engineering, convened on January 28–30, 1912 (Erk, 2004, p. 54).

In mid-April 1915, the cultural plow of the SFP, designed by K. G. Schindler during 1911–1915, were tested in the presence of representatives of the Society of Western Zemstvos, the "Worker" partnership and farmers, on two plots of land with an area of 100 sq. fathoms of the peasant Matvey Yursky in the village Demeevka of the Kiev district of the Kiev province. According to some criteria, it turned out to be preferable in comparison with the existing analogs "... Sakka plows and Russian copies ..." (P.P., 1915, p. 346).

At the competition organized in 1912 by the Moscow provincial zemstvo for the construction of a rational peasant plow, the one created by K. G. Schindler plow OK 7

manufactured by the Bryansk plant. The standard of construction K. G. Schindler plows was confirmed by the All-Russian Agricultural Exhibition held on May 29 – October 15, 1913 in Kiev. This was confirmed by the exhibit made by the Kolomensky plant with an original front end of a scooter and a parset dump of a special shape (Yaroshevich, 1914, p. 236). In addition, the improved cultivator designed by K. G. Schindler, who united the possible harrows, represented by the partnership "Worker". The organizing committee of the exhibition also noted the reaper-loader, improved by the scientist. High agrotechnical qualities were shown during tests at the Omsk machine-building station at the end of the summer of 1913 by the colonist plow of the Kolomensky plant of the K2 brand with a blade designed by K. G. Schindler. High competitive capabilities of plows designed by K. G. Schindler was confirmed by the corresponding competitive tests from 10 plants carried out in two stages (June 3–4 and September 4–9, 1915) by the Kiev Association of Western Zemstvos. In terms of plow lightness and productivity (0.55–0.77 dessiatines per day), he peremptorily took first place and outstripped the widely advertised foreign model of the Sakka type.

K. G. Schindler justly achieved his triumph as a designer at the First All-Russian Exhibition of Agricultural Machines of Domestic Production, which opened in Moscow on October 11, 1915, where the "Schindler's" plow of the "Worker" partnership No. 35 was noticed. At the exhibition, the scientist presented a whole a series of his inventions. So, among a large group of plows of the Sakka type, he presented some plows from the "Worker" partnership. It could be designated as an attempt to create an original self-propelled front plow. The designer managed to achieve a hinged connection of the rack with the beam of the plow body.

This, among other things, made it easier to carry out the correct assembly of the plow at the factory. Although, at the same time, the front of the plow was a complex device, not very convenient for machine. A very detailed assessment of the single-body plows created by K. G. Schindler under the auspices of the "Worker" partnership was given by V. D. Koval in a special publication "On the plow of the "Worker" partnership on the pages of "Agricultural Gazette" No. 44, 1915. He emphasizes that its appeared not only "... in a difficult time for the Russian agricultural engineering industry ...", but also "... its had a number of original features in constructive part" thereby refuting the well-established idea that there was no better Sakka plow for tillage (Koval, 1915, p. 1202). K. G. Schindler's new plow, with its appearance and design solutions, gave grounds for its further improvement.

The February bourgeois-democratic revolution of 1917 in tsarist Russia made changes in the life of the scientist. There is every reason to believe that K. G. Schindler accepted it and even planned to return to Kiev to teach at the KPI. On March 21, 1917, an emergency meeting of the Council of Professors of the KPI took place, at which a corresponding Commission was created from representatives of the professors and students. The participants also made a decision "... on the return of the professors dismissed in 1911 during the period of student unrest" (At Polytechnic, 1917, p. 3). A

corresponding petition was also sent to K. G. Schindler, but his move to Kiev became actually impossible due to rapidly developing events.

Until 1919, the scientist worked in various private institutions in Russia that were engaged in the import, sale and manufacture of agricultural machinery. In 1919, he emigrated to England, where he acted as an authorized representative of "Agryunion", as well as director of the British company "Agryunion Limited". In August 1921, he moved to Czechoslovakia, where he became a member of the council of the authoritative emigrant body – the Russian Academic Group, and from October 1921 – of the Council of Russian Professors under the Committee for the Education of Russian Students in Czechoslovakia under the Ministry of Foreign Affairs. He headed the Department of Natural and Agronomic Sciences of the Academic College. In 1921–1922, he lectured at Czech agricultural courses, and also headed the Russian Agricultural Club in Prague. In 1922–1928, he headed the Agricultural Department, the Cathedra of Mechanical Engineering of the Russian Institute of Agricultural Cooperation in Prague. Concurrently, he was a Professor at the Cathedra of Agricultural Engineering Science of the Agronomy and Forestry Department of the Ukrainian Economic Academy in Podebrady, where he created the Cathedra of Agricultural Engineering Science, and in 1924 – a cabinet for practical training. For various reasons, he was forced to leave his job at both universities. He received an invitation to teach in several leading educational institutions in Europe and America, but refused for various reasons. Until the end of life, he worked on the improvement and development of new designs of tillage machines. K. G. Schindler died in 1940 and was buried in Prague.

The conducted research allowed the creative heritage of K. G. Schindler for the formation of agricultural mechanics, theory and practice of testing of the agricultural machines and tools, conditionally divided into periods:

the first (1887–1898) – the formation of scientific interests under the guidance of a corresponding member of the Imperial St. Petersburg Academy of Sciences N. Ye. Zhukovsky at the Imperial Moscow Technical School. Consolidation of the acquired knowledge by the mechanic of the Gardenin brothers' sugar factory (1893–1895); during a seven-month trip to Germany, Austria and Switzerland (1895); private work on the installation of equipment in factories of the Central Industrial Region (1896); business trips from the Department of Agriculture to Germany, France, England, North America (1897–1898). The experience of competitive examinations at the Butyrsky Khutor of the Moscow Agricultural Institute (1896–1897) for testing agricultural machines and tools;

the second (1889–1911) – theoretical and methodological, practical, research and educational activities on the formation and development of agricultural mechanics for the needs of testing agricultural machines and tools of agronomic orientation with work at the corresponding station at the KhTI of Emperor Alexander III (1898-1899) and organizations, as well as the leadership of the specialized KPI (1900–1911). Organization of carrying out and instrumental and methodological support of

competitions-tests of agricultural machines and implements throughout the European part of the Russian Empire and, first of all, the Ukrainian provinces (1902–1910). The beginning of theoretical and design developments regarding the plow blade, which was realized in a dissertation defended in 1905 and a series of fundamental monographs. Outstanding scientific and educational activities for the training of specialists for the needs of agriculture and especially – testing of agricultural machines and implements;

the third (1911–1919) – commissioning activities in the trade of agricultural machines of the "Rabotnik" partnership in St. Petersburg and consulting of their production at supplier factories. Systematic design work on the creation of various types of plows, seeders, reaping machines and cultivators, which was recognized at various regional competitions and all-Russian exhibitions. Bryansk and Kolomna plants began their mass production;

the fourth (1919–1940) – an attempt to organize the export of agricultural machines and implements from England to Soviet Russia. Teaching, scientific and design activities for the training of emigrant Russian and Ukrainian youth in Czechoslovakia. Preparation of a series of publications, which, first of all, summed up many years of research on the foundations of mechanical engineering and the guiding principles of the rational use of agricultural machines and tools (unfortunately, they remained in manuscripts). Continues to develop new designs of tillage machines (1930–1940). The most famous of them is the moto-cultivating plow – "steel shaft", which was patented in Czechoslovakia and Poland.

In the aggregate of the above, it can be argued that, based on his discoveries in the field of agricultural mechanics and especially agricultural engineering, he has the right to claim personalities – "historical elites", and not as perceived for a long time by secondary personalities. He achieved his greatest scientific achievements while working in the Ukrainian lands at the KhTI and KPI (1898–1911).

Conclusions.

On the basis of the conducted research a conditional periodization of K. G. Schindler's contribution to the theory and practice of testing the agricultural machines and tools, as well as the formation of agricultural mechanics in Ukraine, is proposed for the first time. It made it possible to assert that the most fruitful scientist in this field was represented, working on the Ukrainian lands in the KhTI (1898–1899) and especially in the KPI (1899–1911). These results became the basis for further research into the period of emigration in Czechoslovakia (1921–1940). It should be noted that, since 1902, K. G. Schindler was directly involved in the design, first for the needs of the testing agricultural machines and tools in the form of improving and creating a series of appropriate instruments, as well as methods for their use. From the second half of 1911 to 1918 he actively designed the agricultural tools, primarily plows. While in exile, he did not continue inventing so successfully, from 1928 until his death.

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Внесок професора К. Г. Шиндлера (1869–1940) в становлення сільськогосподарської механіки, теорії та практики випробувань землеробських машин і знарядь в Україні

Анотація. *В статті висвітлено життєвий і творчий шлях видатного вітчизняного вченого, теоретика, методолога і практика*

сільськогосподарського машинобудування К. Г. Шиндлера, пов'язаний зі становленням сільськогосподарської механіки в Україні. Методологічну основу дослідження склали принципи історизму, науковості і об'єктивності у висвітленні явищ минулого на базі комплексного використання загальнонаукових, спеціальних, міждисциплінарних методів. Вперше введено до наукового обігу низку документів з російських і українських архівів, які відображають окремі факти професійної біографії вченого. Охарактеризовано основні напрями плідної педагогічної і наукової діяльності К. Г. Шиндлера, ключові сегменти його творчих пошуків, які визначили подальший розвиток сільськогосподарського машинобудування, його лідерство в науковому співтоваристві. Доведено, що професору К. Г. Шиндлеру належить першість в заснуванні Станції випробувань землеробських машині і знарядь агрономічної спрямованості при Київському політехнічному інституті, яка забезпечила можливість студентам сільськогосподарського і механічного факультетів ознайомитися з існуючими типами і конструкціями ґрунтообробних механізмів, системно відпрацьовувати методи їх дослідження. Окрім того, станцією здійснювалася наукова робота з вивчення окремих питань механізації сільського господарства, розробки методик і приладів для проведення випробувань землеробських машин і знарядь. Відпрацьовані вченим вперше в Європі на початку минулого століття сім функцій дослідної станції агрономічного типу стали орієнтиром для багатьох поколінь дослідників сільськогосподарської техніки. К. Г. Шиндлер першим у світі теоретично обґрунтував необхідність удосконалення конструкції ґрунтообробної техніки залежно від ґрунтово-кліматичних умов, зробив вагомий внесок в теорію деформації ґрунту полицею корпусу плуга. Окрім того, удосконалив динамометр Сакка, розробив контрольний динамометр для провірки тягових динамометрів та інші прилади, удосконалив існуючі і розробив нові конструкції ґрунтообробних машин. К. Г. Шиндлер першим в Україні почав викладати курс сільськогосподарського машинобудування.

Ключові слова: *К. Г. Шиндлер; сільськогосподарська промисловість; станція випробувань землеробських машин і знарядь; Київський політехнічний інститут*

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Вклад профессора К. Г. Шиндлера (1869–1940) в становление сельскохозяйственной механики, теории и практики испытаний земледельческих машин и орудий в Украине

Аннотация. *В статье представлен жизненный и творческий путь выдающегося отечественного ученого, теоретика, методолога и практика сельскохозяйственного машиностроения К. Г. Шиндлера, связанный со становлением сельскохозяйственной механики в Украине. Методологическую основу исследования составили принципы историзма, научности и объективности в освещении явлений прошлого на базе комплексного использования общенаучных, специальных, междисциплинарных методов. Впервые введено в научный оборот ряд документов из российских и украинских архивов, отражающие отдельные факты профессиональной биографии ученого. Охарактеризованы основные направления плодотворной педагогической и научной деятельности К. Г. Шиндлера, ключевые сегменты его творческих поисков, которые определили дальнейшее развитие сельскохозяйственного машиностроения, его лидерство в научном сообществе. Доказано, что профессору К. Г. Шиндлеру принадлежит первенство в создании Станции испытаний земледельческих машин и орудий агрономической направленности при Киевском политехническом институте, которая обеспечила возможность студентам сельскохозяйственного и механического факультетов ознакомиться с существующими типами и конструкциями почвообрабатывающих механизмов, системно отрабатывать методы их исследования. Кроме того, станцией осуществлялась научная работа по изучению отдельных вопросов механизации сельского хозяйства, разработки методик и приборов для проведения испытаний земледельческих машин и орудий. Отработанные ученым впервые в Европе в начале прошлого века семь функций опытной станции агрономического типа стали ориентиром для многих поколений исследователей сельскохозяйственной техники. К. Г. Шиндлер первым в мире теоретически обосновал необходимость усовершенствования конструкции почвообрабатывающей техники в зависимости от почвенно-климатических условий, внес весомый вклад в теорию деформации почвы полкой корпуса плуга. Кроме того, усовершенствовал динамометр Сакка, разработал контрольный динамометр для провирки тяговых динамометров и другие приборы, усовершенствовал существующие и разработал новые конструкции почвообрабатывающих машин. К. Г. Шиндлер первым в Украине начал преподавать курс сельскохозяйственного машиностроения.*

Ключевые слова: *К. Г. Шиндлер; сельскохозяйственная промышленность; станция испытаний земледельческих машин и орудий; Киевский политехнический институт*

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Theoretical and practical aspects of the identification of the bladed weapon on the example of the SG 98/05 bayonet to the Mauser rifle based on metal science research

Abstract. *The article examines the studies of the bayonet fragment with severe damages of metal found in the city Kremenchuk (Ukraine) in one of the canals on the outskirts of the city, near the Dnipro River. Theoretical research to study blade weapons of the World War I period and the typology of the bayonets of that period, which made it possible to put forward an assumption about the possible identification of the object as a modified bayonet to the Mauser rifle has been carried out. Metal science expert examination was based on X-ray fluorescence spectrometry to determine the concentration of elements in the sample from the cleaned part of the blade. Analysis of the chemical composition showed that the blade was made of hardened carbon steel alloyed with silicon, chromium, manganese, nickel and copper. Measure results of the chemical composition of the object correspond to steel for castings of grade 55L with an average blade hardness of 42 HRC. Manufacturing technology of the casting corresponds to the end of the XIX – the beginning of the XX century with the use of converter production. The bayonet blade was subjected to strengthening heat treatment in the form of hardening and medium tempering. Metallographic analysis showed that the research object of blade fragment suffered*

corrosion cracking between crystals or along the body of grains, indicating a long stay in silty deposits. The identification of the research object has been carried out using applied technologies based on visual inspection with a description of the state of conservation and comparison with the results reflected in scientific periodicals; metal science expertise; determination of weight and size characteristics and their compliance with the original, including experimental reconstruction, which identifies the preserved fragment with the original drawing at the control points. A comparison of the chemical composition of the blade steel and the "Haenel" steel, differing in concentration and additional alloying elements has been made. The remains of the royal monogram imprint of the stamp and the absence of the regimental stamp have become the basis for searching through catalogs of registered bayonets. This allowed the identification of the object under study as part of the German imperial modified bayonet model 1898/1905 for the Mauser rifle, which was manufactured in the period from 1915 to 1918. Prospects for further research are seen in an increase in the number of metal science examinations for more accurate identification of discovered specimens.

Keywords: *expert examination; age determination; archaeometallurgy; experimental reconstruction; stamp; "Butcher"*

Introduction.

The current state and prospects for the study of blade weapons of the World War I period have not been sufficiently reflected in scientific periodicals. While highlighting this issue, attention should be paid to the publication (Bennett, 2019a), which describes the two main types of bayonets that were used in the Imperial German Army. The author focuses on setting out the origins of this type of weapon and explaining their current use, that is, the article is more overview in nature. The basic research on this topic is the work of Anthony Carter (Carter, 1984), summarizing the known information about the SG 98/05 bayonet and its prototype SG 98/02, which have much in common in the design of the main elements. The works (Lübbe, 2000; Rüdiger, 1994/2000) contain close-ups of manufacturer's stamps, markings and individual parts, which can help in identifying each specific bayonet. Presented albums and catalogs are valuable reference books for collectors of bayonets at the same time metal science examination would enhance the subject of the article under consideration. Nowadays, scientific interest in the bayonet is very limited in the context of the rapid and sustainable development of weapons, which has been such a noticeable sign of war since the mid-19th century, and its impact on the nature of the battle is barely noticeable (Stone, 2016).

Publications (Ballard & Bennett, 2017; Ballard, 2018) are devoted to an overview of the weight characteristics of the British Army bayonets, which are based on a statistical analysis of data on the compliance with the required minimum and maximum weight range of the finished product. Such an approach does not allow the identification of specimens that are in a poor state of conservation or which integrity

has been disintegrated. The article (Bennett, 2019b) shows the history and characteristics of the Ottoman bayonets of the American Peabody-Martini rifle. These three bayonets provide a classic illustration of the bayonets' typology of this period, without thoroughly examining the metal they were made of.

It should be noted on the metallographic analysis of two knives found in Kobilić (Republic of Croatia), presented under the authorship of (Thiele, Hošek, Antonić, & Rácz, 2017). However, there is no data on the chemical composition of these knives, which is important from the point of view of a precise study of products. The paper (Hošek, Bárta, & Šmerda, 2017) shows the application of metallographic analysis to the study of a sword from Kyjov (Czech Republic). Experimental reconstruction made it possible to obtain technological information in the production of this type of weapon, but questions arise on the compliance with the manufacturing time.

The prospects of researches in the field of archaeometallurgy using various methods of spectroscopic analysis are discussed in some scientific publications (Pearce, 2016). The author notes the importance of greater use of analytical data by archaeologists and, therefore, ultimately to better identification of samples. In particular, the article (Welton, 2016) overestimates the functional properties of 52 early Anglo-Saxon spearheads and 118 knives, also rethinking their technological properties based on the determination of the carbon and phosphorus content in wrought iron. Practical achievements, except local thematic studies, have not yet been spread in the scientific community (Charlton, 2015), that actualizes work in this direction. There is a need for a thorough study of objects using applied technologies.

The aim of the paper is to identify the object of research as part of a modified bayonet (cleaver bayonet, knife bayonet) of 1898/1905 (SG 98/05) to the 1898 Mauser rifle.

Achieving this goal necessitated the following tasks:

– historical investigation and identification of a probable bayonet fragment;

– determination of chemical composition; metallographic analysis and reproduction of the technological scheme of manufacture.

Research methods.

A fragment of blade weapon with significant damage was provided for the study (Fig. 1). The handle and part of the blade are preserved. There are wood particles, two metal screws, and the remains of a button on the handle. The sample was found in Kremenchuk (Ukraine) in one of the canals on the outskirts of the city, near the Dnipro River.

X-ray fluorescence spectrometry (RFS, XRF) GOST 28033–89, which is used to determine the concentrations of elements in the range from 0.001% to 100% in various substances has been used.

Quantitative X-ray fluorescence analysis has high accuracy and reproducibility of results, provided that the requirements for representativeness of the sample are met. High accuracy with low analysis costs is guaranteed by the stability of modern

instruments, which eliminates the need for repeated measurements or frequent recalibrations. The quantitative analysis is based on the dependence of the intensity (I) of characteristic X-ray radiation on waves of various wavelengths. The nature of the dependence is experimentally established by calibration, that is, by measuring the intensity of characteristic fluorescence in several reference (standard) samples with a precisely known concentration (C) of the element that is being determined. The recalculation of the measured intensities of the elements of the investigated object in the unit of concentration is based on the performed calibration and is described mathematically using the calibration function in the form $I = aC + b$. The result of quantitative analysis is the exact value of the concentration of the element in the test object, which is expressed in %, ppm (g/t), g/kg and mg/l.

Figure 1. General view of the research object (photo taken by the authors in 2021).

The qualitative analysis is based on the presence or absence of lines of characteristic radiation of the element in the sample spectrum. An element is considered available in the investigated object if less than two lines of characteristic radiation are detected in the spectrum. The identification of these lines of elements is carried out by setting the wavelengths of the spectrum peaks and searching for the found values in the database of X-ray lines. This operation is carried out by computer means. The analysis result is presented as a list of available elements in the sample and the elements presented in the sample in very small quantities (traces).

The identification of a substance is carried out to establish the correspondence between the composition and certain physical properties of the investigated and reference samples. This type of analysis is important when looking for any difference in the composition of the two samples. X-ray fluorescence spectrometry allows a detailed comparison of samples by the characteristic spectra of the elements, as well as by the intensity of the background (bremsstrahlung) radiation and by the shape of the Compton scattering bands. This is important if the chemical composition of two samples is identical according to the results of quantitative analysis, but the samples differ in other properties, in particular, grain size, crystallite size, surface roughness,

porosity, moisture, the presence of crystallization water, polishing quality, spray thickness, etc. Identification is performed on the basis of careful comparison of spectra, without the need to know the chemical composition of the sample. Any difference in the compared spectra certainly indicates a difference between the research object and the standard. The result of such research is an accurate confirmation or disproof of the identity of the two samples.

For carrying out experimental researches, serial and special laboratory equipment such as a forensic line for photography and a built-in digital camera; angle grinder with modified stable for it; stationary Rockwell hardness tester NOVOTEST TC–P; electronic Vernier caliper Miol Premium 150 mm (15–241) Digital Microscope USB 500X Black as well as X-ray fluorescent spectral analyzer ElvaX Plus were used. The ElvaX Plus device is designed for rapid, quantitative and qualitative analysis of the composition of metal alloys, powders, liquids, bioassays for the content of chemical elements from sodium (Z=11) to uranium (Z=92) in a wide range of concentrations.

Portable X-ray fluorescence analyzer ElvaX Plus is a new generation of analytical equipment for high-precision analysis of the elemental composition of various substances. ElvaX Plus is a benchtop energy dispersive X-ray fluorescence spectrometer that does not require liquid nitrogen for operation and storage. The spectrometer allows carrying out a quick-look non-destructive elemental analysis of a substance at all stages of the production cycle or laboratory research without preliminary sample preparation. The device is contained in the State Register of Measuring Instruments approved for use in Ukraine under the number U1411–01. The device is contained in the State Register of Measuring Instruments approved for use in Ukraine under the number U1411–01. Certificate of Conformity to the Approved Type of Equipment and Measuring Instruments is No. UA–MI/1–971–2001. The results obtained by X-ray fluorescence spectrometry (XRF, RFA) fully meet the requirements for the accuracy of the analysis according to category III (OST 41–08–205–99).

Historical investigation and analytical comparison of the typology of a probable bayonet part.

Since September 16, 1915, by order of the Military Department of the German Empire, the 1898/1905 model bayonet has been modified by introducing a combat bayonet with double edged blade, first in foot troops and jaeger troops, and then in the entire army (Fig. 2).

Since 1915, the bayonet has been produced with a small recess for the gun barrel at the top of the guard and a protective plate on the handle (Bennett, 2019a). Since 1916, the mass production of the model began. This model was the most widely used German bayonet during the World War I. The people called the bayonet “Butcher”, which means “butcher”, since the blade of this bayonet resembled a butcher’s knife in its shape.

During World War I, bayonets of this model were supplied to Turkey along with 1898 Mauser rifles (Bennett, 2019b). After World War I, the 1898/1905 model bayonet

continued to be used in the Reichswehr and the police, remaining in service with individual units until World War II, despite the fact that already from 1923 it was ordered to replace all bayonets of this model in the army with model bayonets 1884/1898 (new type). In addition to Germany, bayonets of this model were also used in Yugoslavia, Turkey, Belgium, Poland, Czechoslovakia, and other countries.

Figure 2. Photo of soldiers with bayonets, model of the year 1898/1905 (Flickr, 2011).

The materials of Anthony Carter (Carter, 1984) were used to highlighting and fixing the elements necessary for the identification of the discovered specimens and their general condition.

At the beginning of the World War I, one significant defect was discovered in the bayonets. While mounting these bayonets on a carbine 98 (Kar 98) and shot, the flame, and gas pressure led to the handle cheeks damage in the form of charring and chipping off pieces of wood. Therefore, it was decided to protect the handle of the bayonets from the flame of shots with a steel plate. Wooden pads were ground off 0.6 mm over the entire inner surface and from the side of the handle spine. The gun barrel half-ring ("ears") was ground off on the crosspiece, the holes for cleaning the ramrod channel in the linings, and the protective plate was aligned (Fig. 3).

Figure 3. SG 98/05 bayonet of old (a.A. – alter Art) and new (n.A. – neuer Art) type (Gotavapen, n. d.).

One can also distinguish transitional and noncombat (ceremonial) bayonets. Transitional SG 98/05 n.A. have a modified crosspiece, but they are not equipped with protective plates. Transitional SG 98/05 a.A. have fire protection plates, but the crosspiece has remained unchanged. The noncombat bayonets of rather low quality are nickel-plated copies of the service ones, in which the blade and the handle are one whole, which gave the finished product considerable strength, since in the ceremonial ones they were fastened separately with a single rivet.

The use of bayonets with a saw on the spine by German troops led to widespread condemnation of Germany by its opponents and the fear of German soldiers to be caught with such a bayonet, which inevitably meant extrajudicial reprisals. In the novel "All Quiet on the Western Front" by E. M. Remark such an episode was described. The final order to remove the saws was issued in early 1918 (Bennett, 2019b). The removal process was organized in repair shops at military units, as well as at arsenals. Comparison of bayonets with a saw, with a ground-off saw and without a saw is shown in Figure 4.

The blade of the bayonet is single-edged, with fuller on both sides and an extension in the lower third. The combat tip contains a sharpening not only from the side of the cutting edge but also to a length of 4 cm from the blade edge on the reverse side. All bayonets were made from a sharpened false blade. The handle is formed by two wooden cheeks, fastened to the shank with two screws. The hole for cleaning the groove in the handle is rectangular, located in the grip cheeks, next to the crosspiece. The head of the handle has a T-shaped groove with a cylindrical expansion and a spring latch with an internal spiral spring. The crosspiece is with the end bent back. Iron sheaths are with a hook and a ball at the end.

Visual inspection revealed that the discovered specimens are a new type of bayonet without a saw. This is evidenced by the presence of remnants of the protective plate and the shape of the gun barrel half-ring. The remainder of the 73 mm blade rejects the possible options for bayonets with a saw and with a ground-off saw since

there is no bevel of the spine of the blade, which began at a distance of 25 mm from the crosspiece.

Figure 4. SG 98/05 bayonet with a saw (m.S. – mit Säge) with a ground-off saw (abg. – sägeabgeschliffen, which means "saw removed") and without a saw (o.S. – ohne Säge) (Gotavapen, n. d.).

A drawing of a fragment of a bayonet is shown in Figure 5. The main dimensions by which the object under study can be identified are indicated. Control points are determined in the form of two metal screws and the remainder of a button. The blade thickness at the heel is 6.6 mm, the thickness of the handle cannot be accurately determined due to significant damage to the wooden cheeks and the protective plate. The weight is 315 g.

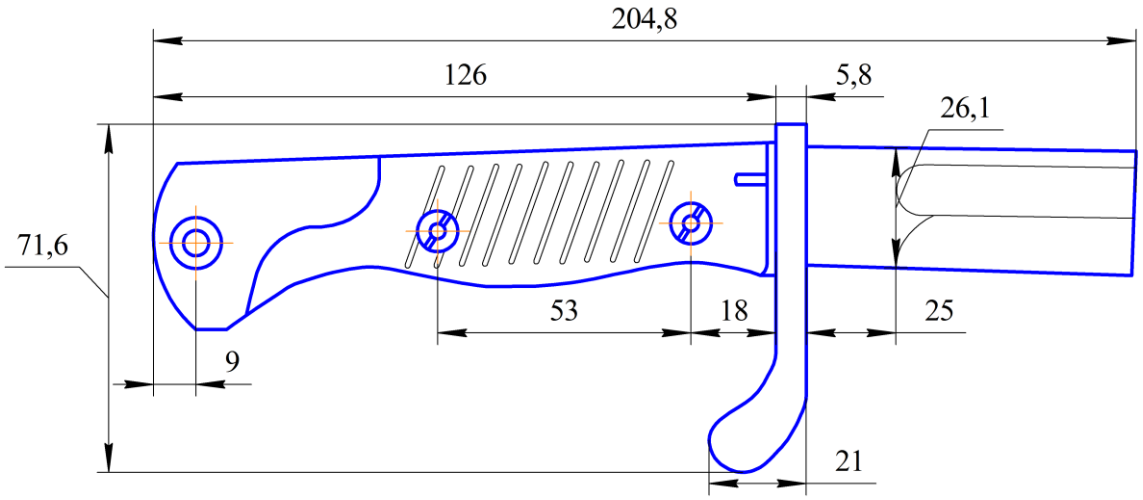


Figure 5. Drawing of the research object.

Experimental bayonet reconstruction based on the identification of the preserved fragment with the original drawing (Fig. 6).

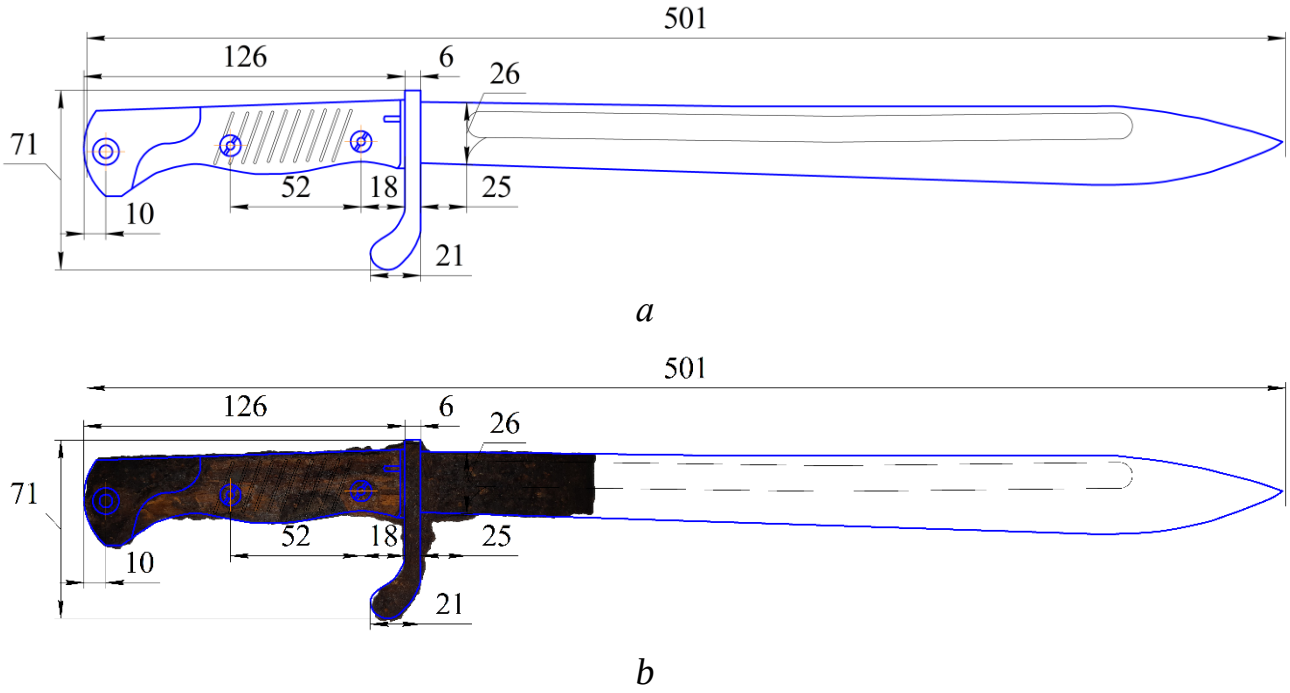


Figure 6. Identification of the research object: *(a)* – original drawing; *(b)* – alignment on a photo scale of the discovered specimens with the original drawings and their coincidence in size and at control points.

It is worth noting the coincidence of the dimensions of the surviving handle, its shape, and the position on it of two metal screws and the remainder of the button, together with a part of the blade, corresponds to the original drawing of the bayonet and confirms the identification of the research object.

Metal science expert examination.

To study the object received for examination, samples were taken from the cleared out part of the blade. The results of the chemical composition measurements of the sample by the XPS (X-ray photoelectron spectroscopy) method are presented in Table 1.

Analysis of the chemical composition showed that the bayonet blade was made of hardened carbon steel alloyed with silicon, chromium, manganese, nickel and copper. Excessive phosphorus content results from strange contamination. A more detailed method using the results of metallographic studies and hardness measurements to estimate the phosphorus content in iron artifacts is presented in (Thiele & Hošek, 2015). Despite certain limitations, the method proposed by the authors can be used to estimate the phosphorus content in archaeological iron studied at the present time or in the past. The article (Thiele, Hošek, Kucypera, & Dévényi, 2015) discusses the

phosphorus content in phosphorus iron, which was used as a special material for welding samples.

Table 1. Results of measuring chemical composition.

Atomic number	Element			Series	Intensity	Concentration, %	55L GOST 977
13	Al	Aluminium	Aluminum	K	2575	0.4227±0.0247	–
14	Si	Silicium	Silicon	K	7123	0.4808±0.0154	0.20–0.52
15	P	Phosphorus	Phosphorus	K	2418	0.0804±0.0073	up to 0.040
16	S	Sulfur	Sulfur	K	3741	0.0442±0.0032	up to 0.045
22	Ti	Titanium	Titanium	K	0	<0.0070	–
23	V	Vanadium	Vanadium	K	963	0.0310±0.0156	–
24	Cr	Chromium	Chrome	K	23477	0.4808±0.0158	up to 0.30
25	Mn	Manganum	Manganese	K	19473	0.6186±0.0161	0.40–0.90
26	Fe	Ferrum	Ferrum	K	3805691	97.3462±0.0279	–
27	Co	Cobaltum	Cobalt	K	0	<0.0486	–
28	Ni	Niccolum	Nickel	K	3223	0.2211±0.0123	up to 0.30
29	Cu	Cuprum	Cuprum	K	4919	0.2384±0.0089	up to 0.30
33	As	Arsenicum	Arsenic	K	1296	0.0236±0.0026	–
41	Nb	Niobium	Niobium	K	0	<0.0027	–
42	Mo	Molybdaenum	Molybdenous	K	319	0.0035±0.0029	–
45	Rh	Rhodium	Rhodium	K	11587	<0.0001	–
74	W	Wolframium	Tungsten	K	130	0.0086±0.0086	–

The chemical composition of the object approximately corresponds to steel for castings grade 55L with an average blade hardness of 42 HRC. The hardness measured at the heel of the blade averaged 17 HRC. Such a difference in hardness may indicate that during quenching the blade was not completely immersed in the quenching medium and structural transformations took place only in the blade part and in the blade tip. The hardness is measured by the Rockwell method – by pressing a diamond cone into the sample under a load of 150 kg. The German analogue of steel 55L according to DIN (Iron and steel: Quality standards 1, 2018) is 1.0554 with the following mechanical properties:

– yield point: 205–412 MPa;
– tensile strength: 450–687 MPa;
– percentage elongation: 12–22%.

The structure contains non-metallic impurity sulfur inclusions. Sulfur is a detrimental impurity that gets into steel from cast iron. When interacting with iron, it forms a chemical compound – ferrous sulphide FeS, which, in turn, forms with iron – a low-melting eutectic with a melting point of 988°C.

In the process of repeated heating for rolling, forging, and heat treatment, the surface of the bayonet is subject to decarburization. Decarburized layer is a ferrite layer in the surface parts of parts, formed by the interaction (burnout) of the metal of the parts from the oxidizer, gases (H_2, H_2O, CO_2, O_2, air) at elevated temperatures. The decarburized layer is formed during heat treatment in air and leads to a decrease in hardness, fatigue ratio and hardening limits, and to the formation of hardening cracks. The depth of the decarburized layer is determined mainly by microstructural analysis methods and microhardness. After the final mechanical metal-working, the decarburized layer is removed and can be identified only in a few places on the bayonet.

The steel production technology of the object corresponds to the period of the late 19th – early 20th centuries with the use of converter production. The simplified technological scheme is: rolling → stamping → machining → heat treatment → final mechanical metal-working.

From the point of view of metal science, it is possible to draw unambiguous conclusions only about such production stages as rolling and heat treatment. Such production stages as stamping and mechanical metal-working are provided on the basis of existing equipment at the time of production and the lowest costs for mass production.

During rolling, the rod passes through the rolls that are at a certain distance from each other. After rolling, the desired cross-sectional profile is obtained. After rolling metal becomes a fibrous structure and has a high flexural strength, which is important for blade weapons. Then a blank of the required length is cut, which enters the stamp.

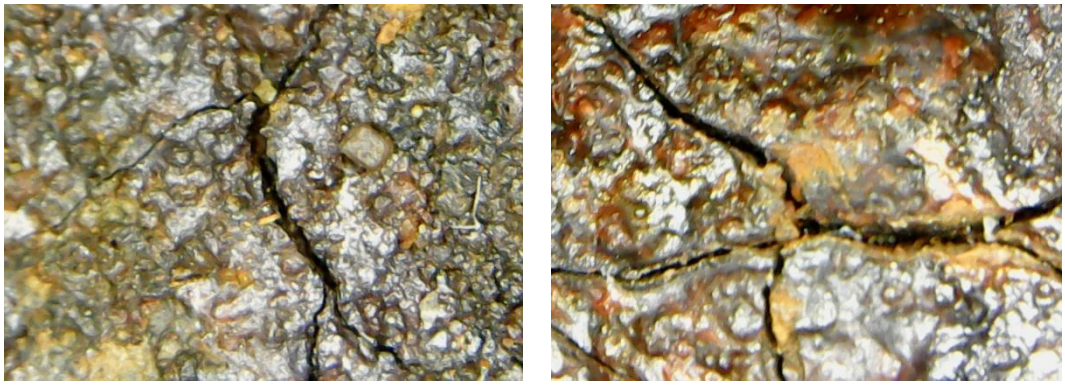
During stamping, a blank of the desired length and cross-section is placed in a stamping mold, which is attached to the hammer frame. Then the hammer with the second half of the stamp hits the blank heated to 1000–1200°C the required number of times to create the shape of a bayonet blade. At this stage, fullers and descents are formed.

Probably, after stamping, the blank still did not have the necessary geometric parameters and required refinement on grinding machines. The need for mechanical processing before heat treatment arises due to the fact that after hardening the steel becomes harder and less amenable to turning and grinding. Thus, in order to reduce costs in the production of any part, manufacturers try to give the most accurate shape of the blank before heat treatment, so that the allowances removed by the final mechanical metal-working are minimal.

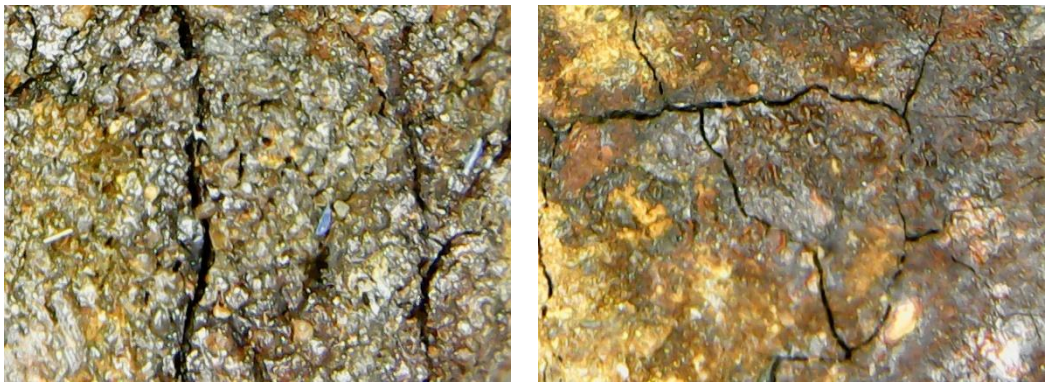
The heat treatment process consists of heating by quenching temperature, pouring into a quenching medium tank, cooling in the quenching, and tempering. After quenching, the blades were placed back in the furnace and medium tempered.

During heat treatment, a scale (iron oxide) and a decarburized layer are formed on the surface of the blade. Final mechanical metal-working removes the scale and partially decarburized layer of steel from the surface of the blade, giving it its final shape. Then the bayonet is collected and sharpened.

Metallographic analysis of the blade showed that the research object suffered corrosion of metals in soils and, partially, liquid corrosion when fully immersed. According to the mechanism, the process is electrochemical corrosion, in which the ionization of metal atoms and the reduction of the oxidizing component of the corrosive medium occurs in more than one act and their rates depend on the electrode potential of the metal. By the nature of corrosion destruction, it is continuous or general uniform corrosion, which occurs at the same rate over the entire surface of the metal. Stress corrosion cracking which is characterized by a relatively uniform distribution of multiple cracks over large areas of the surface has been observed. At each stage of the development of this type of corrosion, cracks arise almost simultaneously from many sources, the connection of which with internal or working stresses is not necessary. Under an optical microscope, it can be seen that cracks propagate between crystals or along the body of grains (Fig. 7).



a



b

Figure 7. Metallographic analysis of the object: *(a)* – on the left; *(b)* – on the right.

As a result, there is irreversible corrosion destruction, which makes it difficult to study the microstructure of the metal in order to identify the phase structure.

Hardness 42 HRC and tempered troostite are typical of medium carbon steel after quenching and medium tempering. Tempered troostite has the form of a needle-like finely dispersed mixture of cementite and ferrite. The result of hardening at 850°C is quenched martensite and a small amount of residual austenite. Such a structure has maximum hardness and strength, but relatively low toughness. As a result of such heat treatment conditions the properties of the blade steel will certainly not correspond to the properties of the blade steel under study. After medium tempering at 350–400°C quenched martensite and retained austenite are transformed into tempering troostite. Steel with such a structure has increased toughness and reduced hardness compared to hardened martensite, but sufficient for bladed weapons.

The hardness of the blade steel at the heel was 17 HRC on average, and the structural components are ferrite and pearlite. This indicates that this part of the blade was not hardened and during the cooling process it was not immersed in a hardening medium. Inhomogeneity in the hardness of steel and a large number of metal inclusions indicate the low quality (by modern standards) of steel. On the other hand, the reduced hardness of the middle part of the blade could be the result of an increased tempering temperature precisely in this part of the blade to increase the toughness of the middle part of the blade.

Results and discussions.

As a comparison of the chemical composition of the blade the data of the company "Haenel", which produced such bayonets (Rüdiger, 1994/2000) are shown in Table 2.

Table 2. Comparison of the chemical composition of the steel of the research object and the control sample steel.

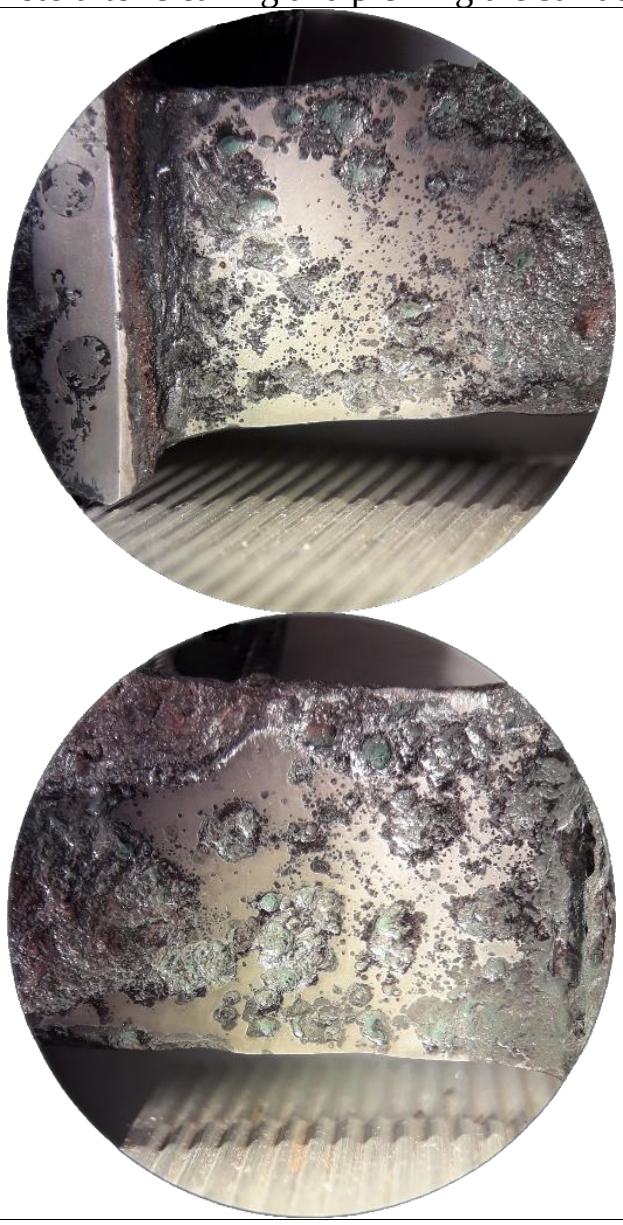
Element	Concentration	
	The research object	**Control sample**
C	0.52–0.6	0.70–0.9
Mn	0.6186±0.0161	0.55
Si	0.4808±0.0154	0.4
Cr	0.4808±0.0158	–
Cu	0.2384±0.0089	0.12
Ni	0.2211±0.0123	–
S	0.0442±0.0032	0.03
P	0.0804±0.0073	0.03

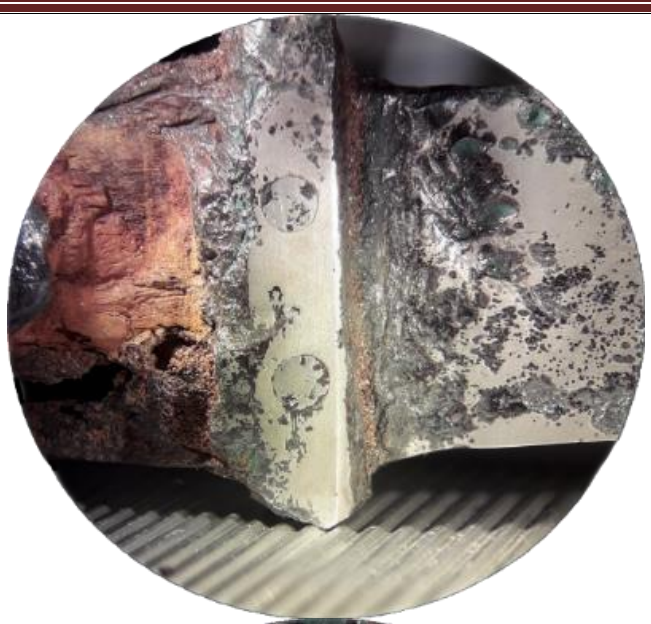
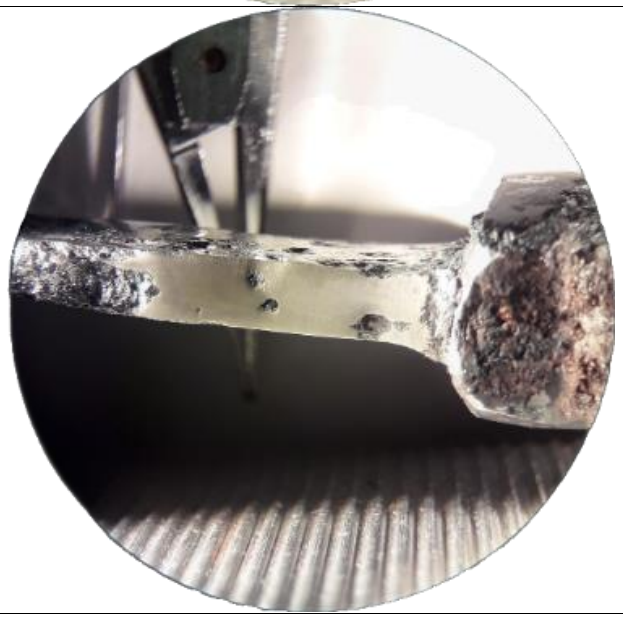
Analyzing the data in the table, it is worth noting the difference in the steel chemical composition of the research object and the steel having been used in the blades of the "Haenel" bayonets.

An important means for more accurate identification of bayonets is their stamping, which at the same time becomes the initial place for the corrosion propagation. Despite the poor state of the object the marks in the places of their possible

location (on the blade heel – the stamp of the manufacturer; on the crosspiece – the regimental stamp, on the spine of the blade – a stamp with the ruler monogram and the year of being entered the bayonet into military service) have not survived (Table 3).

Table 3. Research results of stamping places.

Stamping place	Photo after cleaning and pickling the surface
Blade heel (manufacturer's stamp)	

Crosspiece (the regimental stamp)	 
The spine of the blade (a stamp of the royal monogram / the year of being entered the bayonet into military service	

Based on the research results, it can be concluded that there are remnants of the stamping imprints on the spine of the blade and that there is no regimental stamp on the crosspiece at all, since the depth of corrosion penetration in this place is small.

There are 40 known bayonet manufacturers, 4 royal monograms (Prussia, Württemberg, Bavaria, Saxony), years of the issue (1904–1918), which made it possible to catalog bayonets (Carter, 1984). According to the research results and search in catalogs, old-style bayonets were excluded; transitional; noncombatant (ceremonial) with saws, and with ground-off saws. Correspondingly, registered bayonets that have the stamps of the manufacturer and the royal monogram, but which do not have the regimental stamp have been sorted (Table 4).

Table 4. Catalog of registered bayonets.

Bayonet	Type	The royal monogram / year of issue	Manufacturer
SG 98/05	n.A.	W/15	Erfurt
SG 98/05	n.A.	W/15	Alex. Coppel
SG 98/05	n.A.	W/15	L.O.Dietrich * Gebr.Hartkopf
SG 98/05	n.A.	W/15	Ferd.Esser * Rich.A.Herder
SG 98/05	n.A.	W/15	Ferd.Esser
SG 98/05	n.A.	W/15	F.W.Holler
SG 98/05	n.A.	W/15	P.D. Luneschloss
SG 98/05	n.A.	W/15	Weyersberg & Co
SG 98/05	n.A.	W/16	Gottlieb Hammesfahr
SG 98/05	n.A.	W/16	Demag
SG 98/05	n.A.	W/16	F.W.Holler
SG 98/05	n.A.	W/17	Gottlieb Hammesfahr
SG 98/05	n.A.	W/17	W.K. & C
SG 98/05	n.A.	W/17	E.&F.Horster
SG 98/05	n.A.	W/17	Demag
SG 98/05	n.A.	W/17	F.Koeller & Co
SG 98/05	n.A.	W/17	Pack Ohliger & Co
SG 98/05	n.A.	W/17	Walter & Co * Gebr.Hartkopf
SG 98/05	n.A.	W/17	Walter & Co
SG 98/05	n.A.	W/17	Walter & Co * Carl Galle
SG 98/05	n.A.	W/18	H.Mundlos & Co * Rich.A.Herder
SG 98/05	n.A	W/18	F.W.Holler
SG 98/05	n.A.	W/18	Alex. Coppel
SG 98/05	n.A.	W/18	Walter & Co

* – blanks manufacturer and finishing treatment manufacturer

As a result, this made it possible to identify 24 possible coincidences for the selected features. All bayonets were manufactured between 1915 and 1918 exclusively in Prussia by specified manufacturers.

Conclusions.

As a result of the carried out complex research, it became possible to identify the bayonet SG 98/05 n.A. (year of production – 1915–1918) for the Mauser 98 (Kar 98) rifle, known as "Butcher". A completed historical investigation, visual inspection, and also determined the weight and size characteristics that made it possible to establish the key criteria by which the identification of the research object have been carried out. The performed X-ray fluorescence spectrometry made it possible to determine the chemical composition of the metal, which makes it possible to recreate the production technology of that time and to establish the steel grade for comparison with the data of the company "Haenel". Metallographic analysis of the blade showed the propagation of corrosion cracks caused by prolonged exposure to an aggressive environment, which led to a poor state of conservation, and, as a result, a lack of a clear stamp imprint. Catalog searching of registered bayonets on the basis of the selected characteristics made it possible to highlight possible options for more perfect identification.

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Conflicts of Interest.

The authors declare no conflict of interest.

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Теоретичні та практичні аспекти ідентифікації клинкової зброї на прикладі багнета SG 98/05 до гвинтівки Маузера на основі металознавчого дослідження

Анотація. *У статті розглянуто дослідження фрагмента багнета з сильним пошкодженням металу, виявленого в м. Кременчук (Україна) в одному із каналів на околиці міста, неподалік річки Дніпро. Було виконано теоретичні дослідження для вивчення холодної зброї часів Першої світової війни та типології багнетів даного періоду, що дало змогу висунути припущення щодо ймовірної ідентифікації об'єкта як модифікованого багнета до гвинтівки Маузера. Металознавча експертиза ґрунтувалась на основі рентгенофлуоресцентної спектрометрії для визначення концентрацій елементів у пробі з очищеної частини клинка. Аналіз хімічного складу показав, що клинок виготовлено з загартованої вуглецевої сталі, легованої кремнієм, хромом, марганцем, нікелем і міддю. Результати вимірювань хімічного складу об'єкта відповідають сталі для відливок марки 55Л з середнім значенням твердості клинка 42 HRC. Технологія виготовлення відливку відповідає кінцю XIX – початку XX сторіччя із застосуванням конвертерного виробництва. Клинок багнета був підданий зміцнювальній термообробці у вигляді гартування та середнього відпуску. Металографічний аналіз показав, що досліджуваний фрагмент клинка зазнав корозійного розтріскування між кристалами або по тілу зерен, що свідчить про тривале перебування в мулистих відкладеннях. Ідентифікація досліджуваного об'єкта здійснювалася із застосуванням прикладних технологій на основі візуального огляду з описом стану збереження та порівнянні з результатами, відображеними в науковій періодиці; металознавчої експертизи; визначенні масогабаритних характеристик і їх відповідності оригіналу, у тому числі експериментальної реконструкції, що ототожнює збережений фрагмент з оригінальним кресленником у контрольних точках. Було виконано порівняння хімічного складу сталі клинка та сталі фірми "Haenel", які відрізняються концентрацією та додатковими легуючими*

елементами. Залишки відбитку клейма королівської монограми та відсутність полкового клейма стали основою пошуку за каталогами зареєстрованих багнетів. Це дозволило ідентифікувати досліджуваний об'єкт як частину німецького імперського модифікованого багнета зразка 1898/1905 до гвинтівки системи Маузера, який був виготовлений у період з 1915 по 1918 рр. Перспективи подальших досліджень вбачаються в збільшенні кількості металознавчих експертиз для більш точної ідентифікації знахідок.

Ключові слова: *експертиза; визначення віку; археометалургія; експериментальна реконструкція; клеймо; "Бучер"*

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Теоретические и практические аспекты идентификации клинкового оружия на примере штыка SG 98/05 к винтовке Маузера на основе металловедческого исследования

Аннотация*. В статье рассмотрены исследования фрагмента штыка с сильным повреждением металла, обнаруженного в г. Кременчуг (Украина) в одном из каналов на окраине города, недалеко от реки Днепр. Было выполнено теоретические исследования для изучения холодного оружия времен Первой мировой войны и типологии штыков данного периода, что позволило выдвинуть предположение о возможной идентификации объекта как модифицированного штыка к винтовке Маузера. Металловедческая экспертиза основывалась на основе рентгенофлуоресцентной спектрометрии для определения концентраций элементов в пробе с очищенной части клинка. Анализ химического состава показал, что клинок изготовлен из закаленной углеродистой стали, легированной кремнием, хромом, марганцем, никелем и медью. Результаты измерений химического состава объекта соответствуют стали для отливок марки 55Л со средним значением твердости клинка 42 HRC. Технология изготовления отливки соответствует концу XIX – начала XX века с применением конвертерного производства. Клинок штыка был подвергнут укрепляющей термообработке в виде закалки и среднего отпуска.*

Металлографический анализ показал, что исследуемый фрагмент клинка пострадал от коррозионного растрескивания между кристаллами или по телу зерен, что свидетельствует о длительном пребывании в илистых отложениях. Идентификация исследуемого объекта осуществлялась с применением прикладных технологий на основе визуального осмотра с описанием состояния сохранности и сравнении с результатами, отраженными в научной периодике; металловедческой экспертизы; определении массогабаритных характеристик и их соответствия оригиналу, в том числе экспериментальной реконструкции, что отождествляет сохраненный фрагмент с оригинальным чертежом в контрольных точках. Было выполнено сравнение химического состава стали клинка и стали фирмы "Haenel", которые отличаются концентрацией и дополнительными легирующими элементами. Остатки отпечатка клейма королевской монограммы и отсутствие полкового клейма стали основой поиска по каталогам зарегистрированных штыков. Это позволило идентифицировать исследуемый объект как часть немецкого имперского модифицированного штыка образца 1898/1905 к винтовке системы Маузера, изготовленного в период с 1915 по 1918 гг. Перспективы дальнейших исследований видятся в увеличении количества металловедческих экспертиз для более точной идентификации находок.

Ключевые слова: *экспертиза; определение возраста; археометаллургия; экспериментальная реконструкция; клеймо; "Бучер"*

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Development and construction of shunting electric locomotives at Dnipropetrovsk electric locomotives plant (1960's – 1970's)

Abstract. *In the article on the basis of the complex analysis of sources and scientific literature the attempt to investigate historical circumstances of development and construction of shunting electric locomotives at the Dnipropetrovsk electric locomotive plant has been made. It was found that during the 1960s and 1970s, the team of designers of the Dnipropetrovsk plant, having strong research and production potential, at the request of the Ministry of Railways of the USSR developed and built unique samples of shunting electric locomotives of the VL41 and VL26 series to meet the needs of Soviet main-line railways with modern high-tech electric vehicles. It is proved that in the absence of thorough experience and, accordingly, the possibility of a rapid technological breakthrough in the development of main-line locomotives, during the experimental operation of shunting electric locomotives VL41 and VL26, several design shortcomings were identified, which led to their further use exclusively on the house tracks of enterprises, and designers of Dnipropetrovsk plant later focused on the development and construction of traction units for industrial application commissioned by the Ministry of Ferrous Metallurgy of the USSR. At the same time, the construction of the main-line railway equipment to the order of the Ministry of Railways allowed the staff of the enterprise to gain valuable experience, which was later used in the implementation of the renewal program of rolling stock of Ukrzaliznytsia. Although today the Dnipropetrovsk plant is in decline, the analysis of historical circumstances of formation and design and technological heritage of electric locomotive construction in Ukraine is of fundamental importance both in the general*

perspective of the development of domestic transport engineering, and the railway industry in particular. Further study of the history of Dnipropetrovsk electric locomotive plant requires clarification of the historical circumstances of institutionalization of the Special Design and Technology Bureau of the enterprise from the creation of industrial electric locomotives and traction units to the development and re-equipment of main traction rolling stock and specialized repair equipment within the state enterprise "Ukrainian Research Design Institute of Electric Locomotive Engineering".

Keywords: *Dnipropetrovsk electric locomotives plant; railway engineering; Switcher; main-line electric locomotives engineering; Soviet railways*

Introduction.

The search for technical solutions aimed at minimizing operating costs and environmental pollution during shunting work is an urgent task of the domestic locomotive industry. Despite numerous theoretical researches of ways of modernization of the locomotives of the ChME3 series most involved in shunting work on the railways of Ukraine and attempts of involvement of the main electric locomotives for shunting work (Ryabov, 2015, p. 69), indicators of their operational efficiency remain unsatisfactory, in addition, the economic disadvantage of using shunting locomotives on electrified sections of railways is the need to maintain for equipment and repair of additional locomotive facilities along with the existing electric locomotive one, which creates additional costs (Krasnobaev & Vanag, 1970, p. 53). During the 1960's and 1980's, the Dnipropetrovsk Electric Locomotive Plant specialized in the production of rail electric vehicles for industrial purposes and had a powerful special design and technology bureau (hereinafter – SDTB), whose team designed semi-autonomous locomotives with combined types of traction and had specific experience in the development of industrial production of VL41 and VL26 shunting electric locomotives of own development, created by order of the Ministry of Railways of the USSR. Since, today in Ukraine the issue of import of hybrid semi-autonomous locomotives manufactured by the Japanese corporation Toshiba (Vasyl, 2019) is relevant, and given the prospect of unification of production activities of the locomotive industry of JSC "Ukrzaliznytsia" by introducing electric shunting traction, reducing the cost of current maintenance of rolling stock and the possibility of using electricity recovery during locomotives braking at train operation, there is a need for a comprehensive analysis of the historical experience of the domestic design school of electrical engineering in dealing with this issue.

Unfortunately, for a long time, the circumstances of the production activity of the Dnipropetrovsk electric locomotives plant did not find their proper coverage in the domestic historiography, the only exception is the book by O. Shatovsky and H. Volneansky (Shatovsky & Volneansky, 1998), as well as articles by the authors (Ruban & Baka, 2020; Ruban, 2020; Ruban & Ponomarenko, 2020). Some issues of the history of electric locomotive construction at the Dnipropetrovsk plant are

presented in engineering surveys of designers of the enterprise (Kuzmenko & Matusevich, 1964; Bichuch & Kuzmenko, 1969; Savysko, 2009), monographs of V. Rakov (Rakov, 1990; 1999), of academician V. Bratash (Bratash et al., 1977). At the same time, most popular scientific and technical publications do not even mention the Dnipropetrovsk electric locomotives plant (Shternov, 1967; Haruk, 2019). Instead, we believe that the analysis of production activities of domestic enterprises of railway engineering is updated because of the need to identify conceptual ways to reconcile their historical design and technological potential with modern needs in the renewal and development of the fleet of traction rolling stock of transport operators of Ukraine.

Thus, the subject of the proposed study is the production activity of the Dnipropetrovsk electric locomotives plant. The chronological boundaries of the study cover the period from the beginning of the development of projects of wide-track shunting electric locomotives with combined types of traction to the actual curtailment of this activity after the modernization of the last shunting electric locomotive VL26 in 1972.

The aim of the article is that on the basis of a comprehensive analysis of sources and scientific literature to reproduce a holistic picture of the preconditions for the development and circumstances of construction of shunting electric locomotives in Ukraine in 1963–1972, which involves solving the following research tasks: first, to clarify the historical circumstances of the Dnipropetrovsk electric locomotives plant development; secondly, to consider preconditions of construction and technical features of domestic shunting electric locomotives; thirdly, to find out the impact of the experience of development and construction of shunting locomotives of the Dnipropetrovsk plant on the design and technology school of main electric locomotive construction in Ukraine.

Research Methods.

The proposed research used general scientific methods and principles of historical research, in particular, historicism, objectivity, continuity, multifactoriality, complexity, and comprehensive knowledge (Fullerton, 2011), which provided a detailed analysis of the historical circumstances of the construction of shunting locomotives at Dnipropetrovsk electric locomotives plant in a clear chronological sequence.

Results and discussion.

The construction of the Dnipropetrovsk locomotive repair plant “Promparovoz”, which was to serve as a repair base for locomotives of domestic transport of metallurgical plants of Ukraine, began in 1933, and in the spring of 1937 the company, designed for annual repairs of 300 locomotives and spare parts, was officially introduced. into operation (Shatovsky & Volneansky, 1998, p. 26). Resolution of the Council of Ministers of the Ukrainian SSR No. 1040 of August 7, 1958, approved the organization of production of industrial electric locomotives at the Dnipropetrovsk

locomotive repair plant, and on November 13, 1958, by order of the Dnipropetrovsk Council of National Economy No. 862-R the enterprise was reorganized into "Dnipropetrovsk electric locomotives plant". According to the order, starting from 1959 it was planned to organize the production of electric locomotives and spare parts for them with the subsequent bringing of the enterprise's capacities to 200 locomotives per year till 1965. The production range consisted of contact four-axle electric locomotives with an adhesive weight of 100 tons and six-axle electric locomotives with an adhesive weight of 150 tons (The State Archive of Dnipropetrovsk Oblast, f. 4593, op. 1, spr. 2, ark. 153–154). In addition to the main activity of development and construction of locomotives, the Dnipropetrovsk plant had orders for the manufacture of electric arc steel furnaces, vibrating screens, as well as traction engines for walking excavators (Shatovsky & Volneansky, 1998, p. 79–81, 96).

Dnipropetrovsk electric locomotive plant (DELP) specialized in the production of electric locomotives for access tracks of mining enterprises and had a powerful special design and technology bureau (hereinafter – SDTB). In 1959, the company began designing and organizing the production of the first in the USSR industrial single-phase electric locomotives with a frequency of 50 Hz high voltage industrial frequency of 10 kW. Along with the repair of the last locomotives, the company built the bodies of the first electric locomotives, and at the end of 1961, the first two four-axle research locomotives of the company's own design were manufactured, which were designated the D100 series. (Rakov, 1999, p. 401–402). At present, the procedure for assigning the types of the first electric locomotives of the Dnipropetrovsk plant has not been precisely documented, however, apparently the digital designation was carried out taking into account the adhesive weight of the locomotive. The electric locomotive had an adhesive weight of 100 tons, a traction force of 16,3 tf, and a speed of 29,9 km/h in hourly mode, and in long-term mode – 10,9 tf and 35 km/h, respectively. The double-pitch body of the locomotive, which became the basis for the future electric locomotives of the plant, provided a good overview during the loading of cars at the location of the side current collectors, and access for maintenance of the power and auxiliary equipment.

After testing the first two electric locomotives of the D100 series on the experimental branch of the Dnipropetrovsk Institute of Railway Engineers, under the leadership of the chief designer of DELP V. Bezruchenko the locomotive design was significantly redesigned, in particular, the shape of the body was simplified (the size of the side bevels was reduced to improve the visibility of the track from the driver's cab), the bogie frame was strengthened and the location of the traction motors was changed to increase the utilization of the adhesive weight. Traction electric motors and drive of auxiliary mechanisms were also replaced on the experimental electric locomotive D100M (Bezruchenko, Grigor'yev, & Matusevich, 1961, p. 7, 10). In total, during 1962–1963, 51 locomotives were built under the renewed project, which received the serial designation D100M (modernized), although the numbering continued from the first two experimental electric locomotives D100. D100M electric locomotives

(Figure 1) were delivered to work on the access tracks of coal mining enterprises, in particular, "Vakhrushevvuhilya" and "Korkinovuhilya" (Rakov, 1999, p. 403–404).

Figure 1. Electric locomotive D100M-006, Dnipropetrovsk Electric Locomotive Plant (1962) (D100M-006, 1962).

AC electric locomotive VL41

Since the reorganization, the Dnipropetrovsk plant has been constantly considering the possibility of building main electric locomotives. In particular, back in July 1959, a group of Dnipropetrovsk designers headed by the first head of SDB B. Kolyushnyk (The State Archive of Dnipropetrovsk Oblast, f. 4593, op. 1, spr. 28, ark. 28) was sent to the Novocherkassk electric locomotive plant to " *study the design of the ignitron installation and control panel of the H-60 electric locomotive* ", also at the enterprise it was planned to organize "*production of freight eight-axle double-powered electric locomotives with a capacity of 4800–5200 kW of VL82 type*" (The State Archive of Dnipropetrovsk Oblast, f. 4593, op. 1, spr. 227, ark. 23–24), the construction of which was later deployed at the Novocherkassk plant (Rakov, 1999, p. 130). In the early 1960s, Dnipropetrovsk designers developed projects for four-axle and six-axle shunting electric locomotives equipped with small diesel generator sets to work at stations with non-electrified low-efficiency tracks. The plan to produce new equipment in 1961 provided for the construction of a four-axle electric locomotive weighing 100 – 120 tons with ignitron rectifiers and an autonomous power plant (Shatovsky & Volneansky, 1998, p. 106). A project of a six-axle shunting electric locomotive with a capacity of 2500 kW with a design speed of 80 km/h, equipped with a diesel generator set with a capacity of 440–588 kW, was also developed (Rakov, 1999, p. 404).

Since DELP during 1962 – 1963 produced a sufficient number of electric locomotives D100M series electrified by a single-phase current system with a voltage of 10 kW, at the suggestion of the head of the Main Department of Locomotive

Industry of the Ministry of Railways of the USSR A. Tyshchenko a decision was made to begin construction at the Dnipropetrovsk plant of shunting electric locomotives of single-phase current of 25 kW for the main railways of the Soviet Union. In order not to stop the construction of electric locomotives at the plant and to make its initial reconstruction minimal, a modified version of a four-axle shunting locomotive, based on an industrial electric locomotive D100M with an ignitron rectifier was proposed as a temporary intermediate type. The first electric locomotive of the new series, designated D92 (later – VL41), was built in 1963. Compared to the prototype of the new locomotive, the traction force was increased (at an hourly mode by 1,1 tf and 2,2 tf – at a long time mode) and the speed was increased by 3,7 km/h and 3,8 km/h, respectively. The power of traction motors increased: at an hourly mode from 355 to 425 kW and from 290 to 380 kW – at a long-time mode, design speed was increased by 30 km/h as well (Rakov, 1999, p. 403, 406). The weight of the electric locomotive D92 (VL41 (Figure 2)) was 92 tons. In the hour mode, it developed a traction force of 17,5 tf and a speed of 34,7 km/h, in the long-time mode – 14,9 tf and 36,5 km/h, respectively. The initial design speed was 100 km/h, and the traction force at this speed was 2,5 tf (Kuzmenko & Matusevich, 1964, p. 22).

Figure 2. Electric locomotive VL41-001, Dnipropetrovsk Electric Locomotive Plant (1963) (VL41-001, 1963).

The mechanical part of the electric locomotive consisted of a body and two two-axle carts. The all-metal body of a welded design from rolled and bent profiles and steel sheets consisted of a frame, a driver's cab, and also two bevels. On each of the carts the body leaned with a flat central and two side supports. Traction and braking

forces were transmitted to the body through the central supports. Four lateral elastic sliding supports transmitted vertical impulse to the trolleys and gave the body transverse stability. The control cabin, as on D100 electric locomotives, was located in the center of the locomotive. The frame of the trolley consisted of boxlike section side frames (340×200 mm), welded from sheet steel 12 mm thick, as well as cast parts made of special steel with a carbon capacity of not more than 0,25%. All parts and components were connected together by welding and subjected to burning. Wheelsets (wheel diameter 1200 mm), driving gear (gear ratio 3,905), and traction motors (NB-406B) were similar to electric locomotives of the VL8 series. Traction gear was helical, double-sided, rigid. The normal diametral pitch is 10 mm, the angle of its inclination is 24^0 37’ 12’’. The gears were made of solid rolled steel and subjected to three-dimensional hardening. The gears were made of 40CrNi steel forgings. The teeth of the gearwheel were subjected to surface hardening. Truck axle boxes are non-pedestal, two-linking with bearings, as at VL60 electric locomotives, bearings are with cylindrical rollers (Kuzmenko & Matusevich, 1964, p. 22). The spring suspension of both carts was the same balanced in the longitudinal direction and consisted of cellar leaf springs connected by longitudinal balancers and end cylindrical springs. The locomotives were equipped with standard devices for controlling the brake system and air distributors No. 270.002. The lever brake system was made with one-sided pressure of the hobs on each wheel. The suspension of the traction engine was of the axial type. To make better use of the electric locomotive's adhesive weight, its engines were mounted on carts so that their spouts were directed towards the middle of the body (Bezruchenko, Grigor'yev & Matusevich, 1961, p. 7).

Electrical and pneumatic equipment was located in two bevels, the driver's cab, on removable bevel hatches, cab roof and under the body. The high-voltage chamber, which housed the rectifier and the engine room, was located in the bevel No. 1. The power transformer, smoothing reactor, and control equipment were located in the bevel No. 2. Two control panels were installed in the driver's cab, the main switch was placed on the detachable hatches and the roof of the driver's cab, two current collectors with disconnector were located. The electric locomotive was equipped with two Ts-13-50 No. 5 fans, one in each bevel, and one axial SVM-5M fan for cooling silicon rectifiers, transient resistors, and a smoothing reactor. Heat removal from ignetrons was carried out by a cooling system with a capacity of 200 liters. The main temperature control equipment and several units were used from serial AC electric locomotives (temperature regulator TSR-48, temperature relay TR-4P, current relay RSE, induction heater IN-1, radiators and main pump). Asymmetric pantograph PN-2 was a single-bow collector weighing 200 kg, designed for a long current of 1000 A and a maximum speed of 110 km/h (Kuzmenko & Matusevich, 1964, p. 23).

The main switch EKG-41 (designed for low-voltage step voltage control on traction motors), which had 29 fixed positions and was similar in design to the main switch ECG-60/20 electric locomotives series VL60, housed 12 contactors with arc suppression and 12 contactors without arc suppression, (Rakov, 1999, p. 405). The

nominal insulation voltage of the cam elements was 3350 V. The single-phase oil transformer OCR-2800/25 had a nominal power of the primary winding of 2260 kW, the no-load voltage of the traction windings was 2 × 1515 V, the voltage of the windings for own needs – 404 and 227 V. The traction winding consisted of two half-phases, each of which was divided into three parts: adjustable, unregulated and boosting, as in the transformer OCR-2200/10. The adjustable part had four pins (three sections). Six rectifiers IVS-300/5, connected in two groups of three connected in parallel in each were used to rectify the current, which was carried out according to the zero-output circuit. (Kuzmenko & Matusevich, 1964, p. 23–24).

In the circuit of traction engines in the absence of transient reactors was included smoothing reactor REDR-2500. Traction motors NB-406B operated at pulsating current, as a result of which their nominal voltage on the terminals, as well as on electric locomotives D100M, was reduced from 1500 to 1200 V, a constant excitation attenuation (92% of maximum) was introduced to pass the alternating current component. The NB-406B electric motor had in an hour mode: power 425 kW, current strength 380 A, armature speed 600 rpm; in long-time mode: power 380 kW, current 340 A, armature rotation 630 rpm. The main switch VOV-25U, phase splitter NB-453, compressors E-500, their electric motors AC-81-6 and electric motors AP-81-4 fan drives were similar to the electric locomotives of VL60 series, the release of 1962 (Rakov, 1999, p. 406). The connection scheme of the traction motors allowed to obtain 29 stages, in addition, the supply winding made it possible to do this with a small number of terminals in the adjustable part of the traction winding. All 29 stages were running, except for full arousal, it was possible to get two stages of attenuation – 75 and 55%. Schemes of control circuits of traction motors, protection of power circuits from excessive loads, short circuits, reverse ignitions in ignitrons and atmospheric overvoltages, and also the scheme of control cabinets of ignitrons were similar to the VL60 electric locomotive (Kuzmenko & Matusevich, 1964, p. 24). The driver's controller had a reversible handle with five positions (“Back”, “0”, “Forward 1st full field”, “Forward 2nd weakened field”) and the main one with seven positions (“0”, “Automatic shutdown”, “Manual shutdown”,”Lock-off”, “Lock start”, “Manual start” and “Automatic start”). The power supply of control and lighting circuits, charging of the accumulator battery was carried out by a constant voltage of 50 V from the statically charging unit consisting of the single-phase transformer and silicon rectifiers. To ensure the charge of the battery, which consisted of 38 elements of KN-100, during the period of the highest load in the control circuits, a scheme developed by engineer Yu. Marchenko was adopted (Kuzmenko & Matusevich, 1964, p. 25).

In January – February 1964 the electric locomotive VL41-001 together with the electric locomotive VL80-007 was tested by the All-Union Research Institute of Railway Transport of the USSR Ministry of Railways (Vsesoyuznyy naukovo-doslidnyy proektno-konstruktors′kyy instytut zaliznychnoho transport; hereinafter – VNIIZhT). The test results showed that at a speed of 70 km/h the electric locomotive VL41 had a worse effect on the track than the electric locomotives of the VL80 series,

and the course of the electric locomotive was uneasy. Given the results of tests, VNIIZhT recommended setting the maximum speed of the electric locomotive VL41 70 km/h. In order to improve the dynamic characteristics of the electric locomotive VL41-065, DELP designers decided to install friction spring shock-absorbers between cross bars of carts and a buffer bar of a body – two and two shock-absorbers with their arrangement on a longitudinal axis of the locomotive. When testing the electric locomotive VL41-066 it was noted that when driving on straight sections, its course was restless due to "friction failure" in the shock absorbers, and when driving curves due to the damping moment the impact of the locomotive on the track increased. In the end, it was decided to abandon the shock absorbers and limit the maximum speed of the locomotive to 70 km/h. In 1963, the Dnipropetrovsk plant produced 28 electric locomotives of the VL41 series (No. 001–028), and in 1964 – 50 (No. 029–078), in total, the company built 78 electric locomotives of the VL41 series (Rakov, 1999, p. 406).

In 1966, one electric locomotive of the VL41 series was converted into a contact-battery locomotive. A two-axle tender with a 648-TNZh-400 battery was attached to the electric locomotive. In the same tender, a part of the electric equipment of the electric locomotive was mounted, which allowed to reduce the load of the wheel pairs of the electric locomotive on the tracks from 23 to 21,5 tons, as well as to facilitate the pass conditions of the locomotive by station tracks with a weak upper structure. The battery was placed in a tender in 12 compartments of 54 cells in the compartment and closed with a metal roof that had hatches for adding water. After re-equipment, the electric locomotive could receive train and shunting modes when receiving energy from the catenary. In train mode, traction motors were powered by a transformer winding with a nominal voltage of 1524 V, and in shunting mode – by a winding with a nominal voltage of 514 V. The battery could be charged from the catenary both in the lay-out and while driving. When powered by traction motors from the battery, the electric locomotive could only operate in shunting mode. Start-up was carried out using rheostats and switching of electric motors from serial-parallel to parallel connection. During 1975–1977 according to the project of the Design Bureau of the Main Department of Locomotive Economy of the USSR Ministry of Railways, 13 electric locomotives of the VL41 series were re-equipped with the replacement of ignetronic rectifiers to silicon ones and received the designation VL41K. (Rakov, 1999, p. 406).

Electric locomotives of the VL41 series (Figure 3) were delivered for shunting work on the East Siberian, Gorky, West Siberian, Moscow, Odessa-Chisinau, North Caucasus, and South-Eastern railways. However, the locomotives were poorly adapted for shunting work: they had insufficient traction weight, high track load, low traction, and speed, as well as in the absence of a contact wire over the individual spare tracks of stations, were limited to use in shunting and export work. VL41 electric locomotives began to be transferred to industrial enterprises of the coal mining industry and the tracks of power plants (with the replacement of transformer windings with voltages from 25 to 10 kV). Most of these locomotives were transferred to the access tracks of

mining and power plants between 1970 and 1975. As of January 1, 1976, there were 24 electric locomotives of the VL41 and VL41K series left on the railways of the USSR Ministry of Railways, of which 18 in the North Caucasus, 4 in the West Siberian, and 2 in the East Siberian. (Rakov, 1999, p. 407).

Figure 3. Electric locomotive VL41-004, Dnipropetrovsk Electric Locomotive Plant (1963) (VL41-004, 1963).

Due to the complexity of operation of shunting electric locomotives VL41 on the main railways of the USSR, Dnipropetrovsk plant returned to the production of industrial electric locomotives AC with a nominal voltage of 10 kW, creating at the end of 1964 as part of the continuation of the series (D100, D100M, D92/VL41) experimental electric locomotive D94-001, which differed from VL41 by increasing the total length, the location of the equipment in the body, the voltage of the primary winding of the transformer and the presence of side current collectors (Bratash et al., 1977, p. 23). According to V. Rakov, the transition of the Dnipropetrovsk plant to the construction of six-axle electric locomotives equipped with diesel generators with internal combustion engines with a capacity of about 552 – 736 kW, which would allow the shunting locomotive to operate freely on non-electrified tracks, would solve the main number of problems that arose during the experimental operation of electric locomotives VL41, however, the further development of the project was stopped due

to the beginning of construction of shunting electric locomotives of a direct current with rechargeable batteries of the VL26 series (Rakov, 1999, p. 407).

DC battery electric locomotive VL26.

In order to replace shunting locomotives with electric locomotives at the stations of electrified sections of railways and at the same time not to incur unreasonable costs for electrification of inactive sections, Baltic Railway engineers initiated the creation of a contact-battery electric locomotive. The great advantage of such locomotives over diesel locomotives was also the absence of noise and smoke, which is especially important when carrying out shunting work within cities. The actual precedent that prompted the beginning of work on the development of contact-battery locomotive was the successful experience of operation of the converted for operation on the battery of an industrial electric locomotive IVKP at the Magnitogorsk Metallurgical Plant (Krasnobaev & Vanag, 1970, p. 54). In 1964, the public design bureau of the Scientific and Technical Society of the Baltic Railway developed a preliminary design of a contact-accumulator shunting electric locomotive with a voltage of 3000 V, which was approved by the commission of the Scientific and Technical Council of the USSR Ministry of Railways. The design and construction of experimental contact-battery electric locomotives were carried out by the Dnipropetrovsk plant. In 1966, the first experimental electric locomotive was built, which received the serial designation VL26 (Figure 4, Figure 5), and during 1966 – 1967 which came into operation on the Dnieper, Sverdlovsk, and Baltic railways, as well as a number of industrial enterprises. (Krasnobaev & Vanag, 1970, p. 54).

Figure 4. Electric locomotive VL26-001, Dnipropetrovsk Electric Locomotive Plant (1966) (Electric locomotive VL26-001,1966).

When designing a new contact-battery electric locomotive, the designers of the Dnipropetrovsk plant developed a fundamentally new scheme of the locomotive, decided on the location of the battery, ventilation system, and equipment layout. Among the main developers of the electric locomotive was the head of the design and installation department of SDTB L. Kuzmenko, group leaders M. Bichuch, V. Frolov, F. Raslin, designers M. Kogai, A. Gurevich, artist-designer V. Zhilko, specialists of the electric machines department V. Zakatov, E. Arshinov, V. Artyukh, I. Matusevych, I. Karlenko, head of the group of electrical appliances department V. Savysko, as well as its designers V. Denisenko, G. Svetlov, V. Chmykhalov, A. Nazarenko, V. Przhepyurko, I. Ryzhenko, group leaders E. Moskvichov, V. Volodarsky, I. Handelman and L. Guzik (Shatovsky & Volneansky, 1998, p. 116). It should be noted that in 1967 one of the electric locomotives VL26-005 was built over time by Komsomol youth brigades to the 50th anniversary of the All-Union Leninist Young Communist League. Enthusiasts of electric machines, wheeled, electric locomotive, blacksmith and foundry shops were especially noted, in particular, only the crews of masters V. Chernega and V. Kurochkin worked in the fund of overtime locomotive for more than 220 standard hours (Shatovsky & Volneansky, 1998, p. 118).

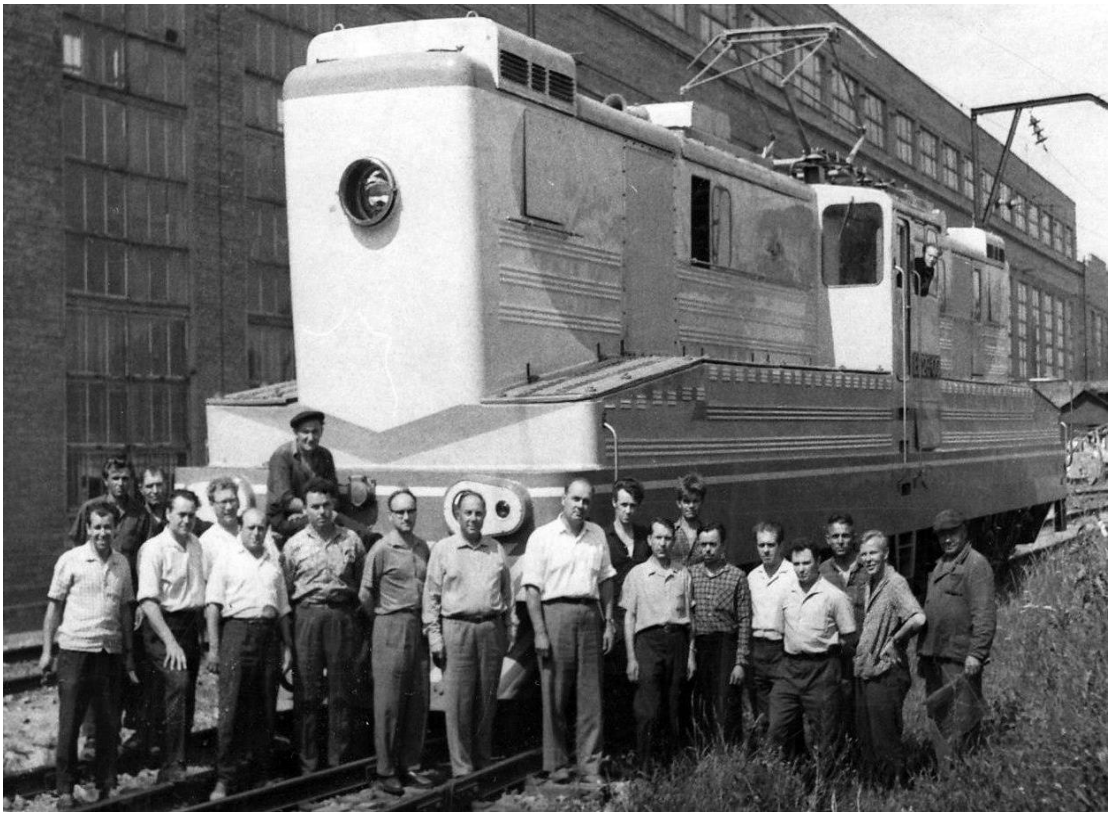

Figure 5. Electric locomotive VL26-001, Dnipropetrovsk Electric Locomotive Plant (1966) (VL26-001, 1966).

The VL26 electric locomotive had an all-metal body, in the middle of which there was the driver's cab (Figure 6). In the side compartments of the lower part of the body

there were sections of the battery, which were charged when working from the catenary. The length of the electric locomotive along the axles of the auto-couplings was 19900 mm, the distance between the pins of the carts was 10000 mm, the wheelbase of the cart was 3900 mm, and the total wheelbase was 13900 mm. The three-axle carts of the electric locomotive had sheet cellar springs and cylindrical springs. The diameter of the wheels was 1050 mm. Transmission from traction engines was one-way, rigid, its gear ratio was 79:16=4,9375. Six DT-7A traction electric motors were installed on the electric locomotive, developed with the participation of the head of the sector of the department of chief technologist Yu. Bereznyak, the head of the SDTB group V. Frolov and the head of the electric machine shop A. Mironov on the basis of electric motors RT-113 of electric trains series ER22 (Shatovsky & Volneansky, 1998, p. 115). At a voltage of 750 V, the DT-7A motors had in an hourly mode: power 235 kW, current 350 A, armature speed 525 rpm; in long-time mode: power 180 kW, current 265 A, armature rotation 570 rpm (Rakov, 1999, p. 396). Initially, electric locomotives used TNZh-550 rechargeable batteries, which consisted of 672 series-connected elements placed in 16 boxes. The nominal voltage of the batteries was 840 V, the capacity was 550 A, weight – 25 tons. Traction motors could be connected in series and series-parallel; the battery, which was charged during the operation of the electric locomotive from the contact drive, was connected in series with them. It was not possible to connect the three motors connected in series directly to the contact wire (without the battery), as this would create unacceptable voltages on the machine collectors.

Figure 6. Electric locomotive VL26-005, Dnipropetrovsk Electric Locomotive Plant (1967) (VL26-005, 1967).

The start was carried out using the starting resistors. In the lay-out, the battery was charged through starting resistors, in which about 2/3 of the energy consumed from the catenary was lost. Electric motors of DK-258A fans were connected to the ballast resistor, which also caused energy losses when powering the electric locomotive from the catenary. At a voltage in the catenary of 3000 V and a series-parallel connection of traction electric motors, the electric locomotive developed a traction force of 24 tf and a speed of 17 km/h in an hourly mode. The design speed was 80 km/h, weight – 126 tons (Krasnobaev & Vanag, 1970, p. 53).

Operation of prototypes of electric locomotives of the VL26 series at the Riga junction of the Baltic Railway confirmed the feasibility of using a locomotive with an autonomous electric power supply in shunting and export work on electrified sections and non-electrified tracks of shunting parks and adjacent depots. However, operational experience also showed that the design of the contact-battery electric locomotive VL26 had several significant shortcomings caused by a number of unsuccessful design decisions (Krasnobaev & Vanag, 1970, p. 55). In particular, during the operation of the electric locomotive in contact mode on heavy shunting work on a shunting hill with trains weighing up to 4000 tons, there were large energy losses, as the train was pushed on the slide at rheostatic positions, in addition, when shifting from the place there were significant pushes due to lack of starting positions. The accepted method of charging the battery led to its overheating during operation of the electric locomotive with high currents, and the lack of control over its charge led to cases of the electric locomotive on non-electrified tracks with an uncharged battery or, conversely, to recharging and boiling of the electrolyte.

The system of auxiliary machines and their mode of operation were also unsuccessful. The voltage of the auxiliary machines was inconsistent with the voltage of the traction motors, which led to the complication of the electrical circuits of the auxiliary machines and caused their unstable operation and the need for duplication. The mode of operation of the fans was inconsistent with the mode of operation of the traction motors and the traction battery, as a result of which they overheated. The power supply circuit of the fan motors from ballast resistance caused significant energy losses.

In 1967, the electric locomotive VL26-005 passed traction and energy tests at the station Sverdlovsk-Sortuvalny (maneuvers, moving the train on the hill) and at the section Sverdlovsk – Pidvoloshna (work with export trains), as a result of which it was found that the existing designs of motor fans, battery boxes and air ducts did not provide effective ventilation of the traction battery (Krasnobaev & Vanag, 1970, p. 55). In general, the following shortcomings of the new locomotive were revealed: a small number of starting positions, which led to large slams during acceleration; when working on batteries and current mode, the speed was only 1,2 km/h, which was much lower than the design speed; due to the large internal resistance of the battery, the voltage at its terminals at an hourly current reduced to 360 – 400 V; when using an electric locomotive to move the train on the hill it was necessary to work on rheostatic positions, which led to additional energy losses; Based on the tests carried out by

VNIIZhT a conclusion was made about the inexpediency of further construction of electric locomotives VL26 with the existing design (Rakov, 1999, p. 397).

In order to eliminate the above shortcomings, the public design bureau of the Scientific and Technical Society of the Baltic Railway has developed a project to modernize electric locomotives VL26. The development of the project was carried out taking into account that modernization should not affect the mechanical part and traction engines of the electric locomotive (Krasnobaev & Vanag, 1970, p. 55). It was envisaged: replacement of starting resistors in the circuits of traction motors with thyristor pulse-width converters with a frequency of 400 Hz in order to eliminate energy losses, application of regenerative-rheostatic braking, increasing the voltage of the battery to 1500 V with the possibility of charging it through the converter (operating frequency 400 Hz) regardless of the current in the circuit of traction motors, as well as replacing the battery TNZh-550 with a more powerful one. It was assumed that the modernized electric locomotive could also be used to service export, transfer, and pickup trains. The locomotive was to provide shunting operation with trains weighing up to 4,000 tons and to drive pickup trains weighing up to 2600 tons on electrified sections (Krasnobaev & Vanag, 1970, p. 55). In 1972, the Dnipropetrovsk plant modernized the electric locomotive VL26-002, which was designated VL26M-002. The locomotive was equipped with an MT-8 rechargeable battery from SAFT (France), which had 1,096 cells. The battery was also modernized on a number of other locomotives of this series, which operated on the Baltic Railway (a TNZh-400 battery with 840 cells was installed). In addition, a series connection of four traction motors was used to increase the speed (Rakov, 1999, p. 397).

The experience of development, construction, and experimental operation of VL26 electric locomotives allowed to outline the prospects for the development of shunting contact-battery locomotives for driving pickup trains with a design speed of 80–90 km/h. In particular, given the then maximum weight of trains of 4000 tons, the leadership of the Baltic Railway, led by Honored Scientist and Engineer of the Latvian SSR Neil Krasnobaev considered as a perspective for the main type was considered a six-axle electric locomotive with an adhesive weight of 126 tons, an hourly power of 1400–1500 kW in contact mode and 300–500 kW – in stand-alone mode. The increased capacity of the contact mode was to provide an opportunity to service export and pickup trains. Two options were considered for heavy rolling work with trains weighing 6000–7000 tons. The first option involved the creation of an eight-axle electric locomotive with an adhesive weight of 176–184 tons, the capacity of 1800–2000 kW in contact mode and 400–550 kW in a stand-alone mode based on a four-axle locomotive and a four-axle booster trailer, which was important not only due to the increase in traction, but also to facilitate the placement of additional equipment. In the long run, the possibility of creating a powerful ten-axle shunting locomotive based on the design of a six-axle locomotive and a four-axle booster trailer was considered. Also promising was the project of a four-axle electric locomotive with an adhesive weight of 72 tons, an hourly capacity of 500–600 kW in contact mode, and 150–250 kW in

stand-alone mode for facilitated shunting and economic work (Krasnobaev & Vanag, 1970, p. 57).

However, due to the imperfection of the new locomotives in the absence of technology for the construction of small batteries, further work on the development and improvement of shunting locomotives at the Dnipropetrovsk plant was deemed inexpedient, and the company focused on the production of traction units for access tracks to the Soviet industry. In the mid-1980s, to ensure shunting and export work on electrified sections of railways and non-electrified station tracks, the main department of locomotive economy of the USSR Ministry of Railways updated the development of projects of semi-autonomous eight-axle DC and AC electric locomotives. The power of electric locomotives in contact mode was to be 4000 kW (1200–1500 kW in stand-alone mode), traction force 32.4 tons, speed 47 km/h, and design speed 100 km/h. Rheostatic and pneumatic braking was provided. When the locomotive was under the contact wire, the batteries had to work in charge mode (Rakov, 1990, p. 211). However, with the onset of the economic crisis of the 1990s and the need to prioritize the production of passenger electric locomotives alongside restrictions on imports of equipment in the absence of convertible currency, the project was not implemented.

Conclusions.

Thus, during the 1960s and 1990s, the staff of the Special Design and Technology Bureau of the Dnipropetrovsk Electric Locomotive Plant, having a strong research and production potential, created unique projects of shunting electric locomotives VL41 and VL26 to meet the needs of the USSR railways with innovative high-tech electric vehicles. Despite the possible perception of the exclusively negative nature of operation of electric locomotives produced by Dnipropetrovsk plant on the main railway transport, it should be noted that the experience of designers confirmed the accuracy of initial technical decisions on the feasibility of creating a shunting locomotive with combined traction on the basis of the first industrial electric locomotives D100. The continuation of this direction of design activity was a joint project with engineers of the Baltic Railway to create contact-battery electric locomotives VL26 of direct current. Despite the fact that due to the technological imperfection of the locomotives of the experimental batch and their components, in particular batteries, electric locomotives VL26 were not widespread on other railways of the USSR, instead, their creation laid the foundations for a promising direction of domestic locomotive construction, updated only in the mid-1980s. Finally, the study of the historical experience of formation and achievements of the design and technological heritage of the Dnipropetrovsk plant is of exceptional importance both in the general perspective of Ukrainian transport engineering, finding ways out of the crisis of the historic enterprise and modernization of the locomotive fleet of the domestic railway industry.

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The authors declare no conflict of interest.

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Розробка та будівництво маневрових електровозів на Дніпропетровському електровозобудівному заводі (1960 – 1970-х рр.)

Анотація. *У статті на підставі комплексного аналізу джерел і наукової літератури здійснено спробу дослідити історичні обставини розробки та будівництва маневрових електровозів на Дніпропетровському електровозобудівному заводі. З'ясовано, що протягом 1960 – 1970-х рр. колектив конструкторів Дніпропетровського заводу, маючи потужний науково-виробничий потенціал, на замовлення Міністерства шляхів сполучення СРСР здійснив розробку й побудував унікальні зразки маневрових електровозів серій ВЛ41 та ВЛ26 для забезпечення потреб радянських магістральних залізниць сучасним високотехнологічним електротранспортом. Доведено, що за відсутності ґрунтовного досвіду й відповідно можливості здійснення стрімкого технологічного прориву в розробці магістральних локомотивів, під час дослідної експлуатації маневрових електровозів ВЛ41 та ВЛ26 було виявлено ряд конструктивних недоліків, які обумовили їх подальше використання виключно на під'їзних коліях підприємств, а конструктори Дніпропетровського заводу в подальшому зосередились на розробці та будівництві тягових агрегатів промислового призначення на замовлення Міністерства чорної металургії СРСР. У той же час будівництво магістральної залізничної техніки на замовлення МШС дозволило колективу підприємства отримати цінний досвід, який згодом був використаний при реалізації програми оновлення рухомого складу Укрзалізниці. Попри те, що нині Дніпропетровський завод перебуває в занепаді, аналіз історичних обставин становлення й конструкторсько-технологічної спадщини електровозобудування в Україні має принципове значення як в загальній перспективі розвитку вітчизняного транспортного машинобудування, так і залізничної галузі зокрема. Подальше дослідження історії Дніпропетровського електровозобудівного заводу потребує з'ясування історичних обставин інституалізації Спеціального конструкторсько-технологічного бюро підприємства від створення промислових електровозів і тягових агрегатів до розробки та переобладнання магістрального тягового*

рухомого складу, а також спеціалізованої ремонтної техніки у рамках державного підприємства "Український науково-дослідний проектно-конструкторський інститут електровозобудування".

Ключові слова: *Дніпропетровський електровозобудівний завод; залізничне машинобудування; маневровий локомотив; магістральне електровозобудування; радянські залізниці*

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Разработка и строительство маневровых электровозов на Днепропетровском электровозостроительном заводе (1960 – 1970-х гг.)

Аннотация. *В статье на основании комплексного анализа источников и научной литературы предпринята попытка исследовать исторические обстоятельства разработки и серийного строительства маневровых электровозов на Днепропетровский электровозостроительном заводе. Установлено, что в течение 1960 – 1970-х гг. коллектив Специального конструкторско-технологического бюро Днепропетровского завода, имея мощный научно-производственный потенциал, по заказу Министерства путей сообщения СССР осуществил разработку и изготовил уникальные маневровые электровозы серий ВЛ41 и ВЛ26 для обеспечения потребностей советских железных дорог современным высокотехнологичным электротранспортом. Доказано, что при отсутствии основательного опыта и соответственно возможности осуществления стремительного технологического прорыва в разработке магистральных локомотивов, при опытной эксплуатации маневровых электровозов ВЛ41 и ВЛ26 был выявлен ряд конструктивных недостатков, которые обусловили их дальнейшее использование исключительно на подъездных путях предприятий, а конструкторы Днепропетровского завода в дальнейшем сосредоточились на разработке и строительстве тяговых агрегатов промышленного назначения по заказу Министерства черной металлургии СССР. В то же время строительство магистральной железнодорожной техники на заказ МПС позволило коллективу Днепропетровского завода получить ценный опыт, который впоследствии был использован при реализации программы обновления подвижного состава Укрзализныци. Несмотря на то, что в настоящее время Днепропетровский завод находится в упадке, анализ исторических обстоятельств становления и конструкторско-технологического наследия электровозостроения в Украине*

имеет принципиальное значение как в общей перспективе развития отечественного транспортного машиностроения, так и железнодорожной отрасли в частности. Дальнейшее исследование истории Днепропетровского электровозостроительного завода требует выяснения исторических обстоятельств институализации Специального конструкторско-технологического бюро предприятия от создания промышленных электровозов и тяговых агрегатов к разработке и переоборудование магистрального тягового подвижного состава, а также специализированной ремонтной техники в рамках государственного предприятия "Украинский научно-исследовательский проектно-конструкторский институт электровозостроения".

Ключевые слова: *Днепропетровский электровозостроительный завод; железнодорожное машиностроение; маневровый локомотив; магистральное электровозостроение; советские железные дороги*

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Analysis of Klavdii Semyonovich Nemeshaev's activities as the Minister of Railways of the Russian Empire

Abstract. *The article continues the series of publications devoted to the assessment of activities of the heads of the Ministry of Railways of the Russian Empire. In this article, the authors attempt to systematize and analyze historical data on the activities of Klavdii Semyonovich Nemeshaev as the Minister of Railways of the Russian Empire. There are numerous biographical studies devoted to K. S. Nemeshaev, but little is known about his activities as a minister, and to date the data are scattered and not systematized. The analysis of archival materials, scientific publications, memoirs of Nemeshaev's contemporaries and colleagues allowed us to conduct a detailed assessment of his activities and ministerial policy. It has been found that despite his short term of office, Nemeshaev's consistent policy and extensive managerial experience allowed him to carry out two significant reforms in a short time. The first one involved redistribution of the state-owned railway lines between separate local administrations and merging them into larger groups, which was important in terms of improving their operations and facilitating the cost efficiency, as well as speeding up freight traffic. In opinion of the authors of this article, another important achievement of Nemeshaev as the Minister of Railways was the establishment in 1906 of the central, local and district committees regulating mass transportation of goods. This was the first centralized measure aimed at managing the rolling stock. Nemeshaev's extensive managerial experience, high erudition and energy also led to prominent outcomes in some other areas of the Ministry operation. Attempts were made to create syndicates of shipowners in river transport. Modernization of river and sea vessels was carried out. Works on projects for the development of the Northern Sea Route has begun. The article also assesses the development and construction of railway*

network in the Russian Empire during Nemeshaev's office, in particular, of the Amur Line and Moscow Encircle Railway, as well as the increase in the capacity of the Trans-Siberian Railway. It has been found out that K. S. Nemeshaev paid great attention to various social aspects of railway employees' activities. The article also highlights the legislative policy of the Ministry of Railways of that period. Nemeshaev's participation in the preparation of the French scientist's Paul Pelliot and the Russian officer's Carl Gustaf Mannerheim joint trip to China has been analyzed. Due to the mass replacement of light and worn-out rails on state-owned railways with heavier ones and the need to discharge a significant number of steam locomotives built in the 1850s and 1860s, an introduction of more powerful steam locomotives was expedient. The article discusses K. S. Nemeshaev's contribution to the development of technology and the introduction of a new type of freight steam locomotive for state-owned railways. Nemeshaev's political views have also been assessed.

Keywords: *transport of the Russian Empire; railway; reforms; Sergey Yulievich Witte; Council of Ministers; SHCH class steam locomotive*

Introduction.

In 1905, the Russian Empire was on the verge of a political, economic, and social crisis. The industrial downturn, deterioration of money circulation, poor harvest, and huge national debt that had grown since the Russian-Turkish War, led to the urgent need to reform activities and authorities. The period characterized by significant importance of the natural economy has ended, and the intensive form of industrial methods' development that became widespread in the XIX century demanded radical innovations in administration and law. Following the abolition of serfdom and farms' transformation into industrial enterprises, an introduction of a new institution of legislative power was required. Dissatisfaction with the government police was exacerbated by military failures (the Russo-Japanese War of 1904–1905), low standard of living suffered by the majority of the population, poverty, as well as by discontent with the existing level of civil liberties; no freedom of speech and the press, equality before the law, or personal inviolability was allowed by the state.

The global economic crisis that worsened at the turn of the century contributed the most to the development of a pessimistic public opinion towards the state economy. The quality of life of the Russian Empire population rapidly deteriorated due to falling prices of grains, the main exported commodity. Finding the way out of the crisis required rapid growth of the industry, which entailed huge costs. This led to the impoverishment of a large peasant class. Population growth and advanced industrialization have deprived a significant portion of the population of any landholdings. 12–14 working hours a day, low wages and a strong influx of people to the cities caused a deterioration of public mood. The ever-growing level of corruption, bureaucracy, officials' negligence and inaction of the state bodies further contributed to the loss of faith in the existing tsarist regime. In addition, the defeat in the Russo-Japanese War of 1904-1905 undermined the international authority of the Russian

Empire and the people's confidence in the viability of the government. The aforementioned factors led to the 1905 revolution and mass protests breaking out from time to time until 1907.

At the beginning of 1905, Sergei Yulievich Witte held a position as the chairman of the Committee of Ministers. The position he held since 1903 was in fact an honorary retirement as the Committee of Ministers had no real significance before the 1905 revolution. He was transferred there from the influential post of the Minister of Finance under the pressure of the gentry-landowner members of the government (mainly V. K. Plehve). The Committee of Ministers authorities had little in common with the modern concept of the Cabinet of Ministers and its range of functions. All the ministers (and the heads of separate units) were acting independently of each other, held personal responsibility for the operation of their departments, and reported directly to the emperor. The Committee of Ministers was not responsible for the activities of separate ministries, nor for the coherence of their policies. Its authority has developed historically and covered various issues, most of which were trivial and unimportant. The detailed list of the matters within the Committee's power was changed continuously, with their total number gradually increasing. The most important area under the Committee's jurisdiction was railway affairs. Decisions on granting concessions for the construction of railways, establishment of railway companies, provision of state guarantees for their shares and bonds, state purchase of railways, etc., were of the highest state and economic importance.

In the summer of 1905, the emperor sent S. Yu. Witte to the United States to conclude the Peace Treaty of Portsmouth with Japan. For the successful conclusion of the peace treaty, he was granted the title of a count. Witte understood the gravity of the situation that occurred in the Russian Empire by the autumn of 1905. Therefore, reporting on the negotiations for the conclusion of the peace treaty with Japan, he took the opportunity to present a note describing the urgent need for political reforms to the emperor Nicholas II. Witte was the initiator of preparing the *October Manifesto* granting basic civil liberties and introducing the State Duma, the institution for the representation of the people (Figure 1).

By the emperor's decree *On Measures to Strengthen Unity in the Activities of Ministries and Main Departments* of October 19, 1905 (Witte, 2003, p. 314.) a new government of the Russian Empire was established, namely the Council of Ministers. It was a single authority that united all ministers (as was mentioned above, before that each minister reported on the matters of his department directly to the emperor). Thus, all ministries and main departments now constituted parts of a single state administration. The Decree also stipulated clear separation of government power from the legislative power: "The Council of Ministers is not to decide on matters that are subject to the jurisdiction of the State Duma and the State Council" (Witte, 1924, pp. 513–514.). The Council comprised the Ministers of the Internal Affairs, Finance, Justice, Trade and Industry, Railways, Public Education, Military Affairs, Naval Affairs, Imperial Court, Foreign Affairs, the Head of the Chief Administration of Land

Organization and Agriculture, the State Controller and the Chief Prosecutor of the Synod. The heads of other departments only participated in the Council meetings regarding matters directly related to authority of their departments. The chairman of the Council of Ministers was not the emperor himself, as was the case before, but a person appointed by him from among the ministers. S. Yu. Witte was the first person to be appointed as the chairman of the Council of Ministers. He had previously held the honorary but still in-name-only position of the chairman of the Committee of Ministers.

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ВЫСОЧАЙШІЙ МАНИФЕСТЪ.

БОЖІЕЮ МИЛОСТІЮ,

МЫ, НИКОЛАЙ ВТОРЫЙ,

ИМПЕРАТОРЪ И САМОДЕРЖЕЦЪ ВСЕРОССІЙСКІЙ,

Царь Польскій, Великій Князь Финляндскій,

и прочая, и прочая, и прочая.

Объявляемъ всѣмъ НАШИМЪ вѣрнымъ подданнымъ:

Смуты и волненія въ столицахъ и во многихъ мѣстностяхъ Имперіи НАШЕЙ великою и тяжкою скорбью преисполняютъ сердце НАШЕ. Благо Россійскаго ГОСУДАРЯ неразрывно съ благомъ народнымъ и печаль народная ЕГО печаль. Отъ волненій, нынѣ возникшихъ, можетъ явиться глубокое нестроеніе народное и угроза цѣлости и единству Державы НАШЕЙ.

Великій обѣтъ Царскаго служенія повелѣваетъ НАМЪ всѣми силами разума и власти НАШЕЙ стремиться къ скорѣйшему прекращенію столь опасной для Государства смуты. Повелѣвъ подлежащимъ властямъ принять мѣры къ устраненію прямыхъ проявленій безпорядка, безчинствъ и насилій, въ охрану людей мирныхъ, стремящихся къ спокойному выполненію лежащаго на каждомъ долга, МЫ, для успѣшнѣйшаго выполненія общихъ преднамѣчаемыхъ НАМИ къ умиротворенію государственной жизни мѣръ, признали необходимымъ объединить дѣятельность высшаго Правительства.

На обязанность Правительства возлагаемъ МЫ выполненіе непреклонной НАШЕЙ воли:

1. Даровать населенію незыблемыя основы гражданской свободы на началахъ дѣйствительной неприкосновенности личности, свободы совѣсти, слова, собраній и союзовъ.

2. Не останавливая предназначенныхъ выборовъ въ Государственную Думу, привлечь теперь же къ участію въ Думѣ, въ мѣрѣ возможности, соотвѣтствующей краткости остающагося до созыва Думы срока, тѣ классы населенія, которые нынѣ совсѣмъ лишены избирательныхъ правъ, предоставивъ, засимъ, дальнѣйшее развитіе начала общаго избирательнаго права вновь установленному законодательному порядку.

и 3. Установить, какъ незыблемое правило, чтобы никакой законъ не могъ воспріять силу безъ одобренія Государственной Думы и чтобы выборнымъ отъ народа обезпечена была возможность дѣйствительнаго участія въ надзорѣ за закономѣрностью дѣйствій поставленныхъ отъ НАСЪ властей.

Призываемъ всѣхъ вѣрныхъ сыновъ Россіи вспомнить долгъ свой передъ Родиною, помочь прекращенію сей неслыханной смуты и вмѣстѣ съ НАМИ напрячь всѣ силы къ возстановленію тишины и мира на родной землѣ.

Данъ въ Петергофѣ въ 17 день Октября, въ лѣто отъ Рождества Христова тысяча девятьсотъ пятое, Царствованія же НАШЕГО въ одиннадцатое.

На подлинномъ Собственною ЕГО ИМПЕРАТОРСКАГО ВЕЛИЧЕСТВА рукою подписано:

„НИКОЛАЙ".

ВЫСОЧАЙШІЯ ПОВЕЛѢНІЯ.

ГОСУДАРЬ ИМПЕРАТОРЪ Высочайше соизволилъ повелѣть Предсѣдателю Комитета Министровъ, Статсъ-Секретарю графу Витте, принять мѣры къ объединенію дѣятельности Министровъ, впредь до утвержденія законопроекта о Совѣтѣ Министровъ.

Figure 1. The October Manifesto issued by Nicholas II of Russia in 1905 (Romanov, 1905).

On October 20, 1905, all major newspapers published His Imperial Majesty's Rescript on the appointment of Count S. Yu. Witte as the Chairman of the Council of Ministers (Ilyin, 2012, p. 343). Witte started selecting the candidates for governmental positions even before the publication. All the reactionaries were dismissed. According to the plan of the Chairman of the Council of Ministers, which was approved by the emperor, the "enlightened" bureaucrats in the government were to be diluted with

liberal public figures. Klavdii Semyonovich Nemeshaev, a railway administrator with considerable experience, was appointed as the Minister of Railways, coming to the post from the position of manager of the state-owned Southwestern Railways (S. V. Ilyin, 2012, p. 350). There is quite a lot of information available about K. S. Nemeshaev, mostly regarding his service as a Southwestern Railways manager. However, the short but important period during which he was in charge of the Ministry of Railways, remains insufficiently explored. Scattered facts on the topic have never been properly systematized and analyzed.

The purpose of this article is to systematize and analyze historical data on the activities of Klavdii Semyonovich Nemeshaev as the Minister of Railways of the Russian Empire.

Research methods.

The article continues the series of publications devoted to the assessment of activities of the heads of the Ministry of Railways of the Russian Empire (Pylypchuk, & Strelko, 2016, 2017a, 2017b, 2018a, 2018b, 2019, 2020). In this article, the authors attempt to systematize and analyze historical data on the activities of Klavdii Semyonovich Nemeshaev as the Minister of Railways of the Russian Empire. There are numerous biographical studies devoted to K. S. Nemeshaev, but little is known about his activities as a minister, and to date the data are scattered and not systematized. The analysis of archival materials, scientific publications, memoirs of Nemeshaev's contemporaries and colleagues allowed us to conduct a detailed assessment of his activities and ministerial policy.

Results and discussion.

Position of the Minister of Railways in S. Yu. Witte's government was the peak of Klavdii Semyonovich Nemeshaev's railway career (Figure 2). He was officially appointed on October 28, 1905. Recalling the appointment, S. Yu. Witte wrote (Witte, 1924, pp. 859–860): "Even before moving to the palace house, I parted with the Minister of Railways, Duke Khilkov, a decent man, an excellent railway worker, but not really a minister of railways. He was a technician practitioner, a nice person, but not a manager at all. Instead, I offered the post of the Minister of Railways to the head of the Southwestern Roads Nemeshaev. I didn't know him much personally, but he had a good reputation as a railway engineer and as an experienced railway manager. The Southwestern Roads were known as Russia's best railways in terms of personnel and commercial profitability, as a remunerative enterprise, and finally, as an example of perfect order. They were mostly created by myself during my service and management there, thus the results of appraisal of local managers were conveyed to me by my former subordinates when I had to meet them, and, consequently, I knew Nemeshaev very well just by those appraisals. Furthermore, I chose Nemeshaev because I knew that he would be pleasant to the emperor. In the old days, when the emperor took his trips along the Southwesterrn roads, he always praised them and spoke well of Nemeshaev. His

Majesty immediately agreed to the dismissal of Duke Khilkov (with whom we had been friends for decades and remained friends until his death) and to the Nemeshaev's appointment to the post of the Minister of Railways. All the strikes and disturbances on the railways occurred during Duke Khilkov's time at the office, and Nemeshaev had to restore order on the railways, as well as restore traffic, which was managed quickly after October 17."

In his analysis of the activities of Witte's Council of Ministers, the famous statesman of the Russian Empire Vladimir Iosifovich Gurko, divided the new government into three groups (Ilyin, 2006, pp. 352–353). According to him, the first group consisted of the Prime minister's henchmen who did not dare to object to him. In his opinion, this group comprised I. P. Shylov, N. N. Kutler, and K. S. Nemeshaev. The second group tried to show independence in managing their departments but in the Council of Ministers they invariably sided with the Prime minister. V. I. Gurko claims that I. I. Tolstoy, V. I. Timiryazev, D. A. Filosofov and V. N. Lamsdorff belonged to this category. The third group was constituted by ministers who were only pro forma members of the Council, namely A. F. Roediger, A. A. Birilyov and V. B. Fredericks. They were direct subordinates to the tsar, but tried not to break the unity of the Council of Ministers and attended its meetings regularly. Gurko concludes: "It is clear from the aforementioned that in the meetings of the Council, Witte was the complete master of the situation and had a well-secured majority on every issue." (Sidelnikov, 1980, pp. 69–70,).

Figure 2. Klavdii Semyonovich Nemeshaev, the Minister of the Ministry of Railways of the Russian Empire from October 28, 1905 to April 28, 1906 (Ministry of Transport of the Russian Federation).

The meetings of the united government were held in the dining room at the state apartment of S. Yu. Witte at 30, Dvortsovaja Naberezhnaja street near the Hermitage (Ilyin, 2012, p. 353). In the middle of the room there was a long table covered with green cloth. The ministers sat down at it. They were seated without rank, randomly, with the exception of two members of the cabinet – the Minister of the Highest Court and Foreign Affairs. The Prime Minister personally invited them to take a seat on his right hand. Duke Obolensky always sat after Lambsdorff, then Filosofov, Kutler, Timiryazev, Durnovo, Vuich, Manukhin, Tolstoy, Rediger, Nemeshaev, and Birilyov. When Kutler, Timiryazev, and Manukhin were made to leave the government, their successors, Nikolsky and Fedorov, took their places, and Manukhin's successor, Akimov, was seated between Birilyov and Shipov.

The first "official" meeting of the Government headed by Count S. Yu. Witte was held on October 29, and the last one was held on April 18 (Ilyin, 2012, p. 359–360). By months, they were distributed as follows: 2 meetings in October, 15 meetings in November, 8 meetings in December, 9 meetings in January, 7 meetings in February, 12 meetings in March, and 4 meetings in April. And this is not counting the three meetings in Tsarskoye Selo in December, February and April, which were dedicated to the electoral law, the establishment of the State Duma and the Council, as well as the basic laws of the Russian Empire. The main final government document was the memoria, or aide-memoire. It contained a summary of the issue and a summary of its discussion. At first, after the discussion that had already taken place, a rough draft of the memoria was drawn up. It was then agreed upon, typed out on a typewriter or in a printing office, signed by the ministers, and presented to the emperor. For the whole time of the office of the Government of S. Yu. Witte, 92 memorials were compiled. They were different in content and volume. Most often, they were accompanying documents to draft legislative acts.

The Council of Ministers was responsible for the legislative work and preliminary consideration of the proposals of ministries, departments, special meetings, committees and commissions on legislative issues submitted to the State Duma and the State Council; discussion of the proposals of ministers on the general ministerial structure and on the replacement of the main posts of higher and local management; consideration of state defense and foreign policy affairs, as well as the affairs of the Ministry of the Imperial Court and the principalities. In addition, the Council of Ministers had significant rights in the field of the state budget and credit. No management measure of general importance could be adopted by the heads of departments other than the Council of Ministers, but the affairs of State defense and foreign policy, as well as the affairs of the Ministry of the Imperial Court and Estates, were actually removed from the Council's jurisdiction. They were submitted to the Council of Ministers only by special orders of the emperor or by the heads of these departments. The audit activities of the National Audit Office, His Imperial Majesty's Own Chancellery, and His Imperial Majesty's Own Chancellery for the Institutions of Empress Maria were also outside the competence of the Council of Ministers.

For the six months of work, the government under S. Yu. Witte has done a lot both in terms of temporary legislation and in the long term for the introduction of the State Duma for discussion. On January 24, 1906, at a meeting of the Council of Ministers, it was decided to draw up a general government program for submitting it to the State Duma for discussion (Ilyin, 2006, p. 378). Each minister (excluding the ministers of the Imperial court and Foreign Affairs) was assigned the task of drawing up a program of legislative initiatives for their department. In March, they were discussed at the general meeting of the Council of Ministers. They reported in the following order: on March 7 the Minister of Finance reported, the Minister of Justice on March 8, the Minister of War on April 10, the Minister of Railways on April 14, the General Manager of Land Management and Agriculture on April 18.

The last Minister of Railways of the Russian Empire, Eduard Bronislavovich Krieger-Voynovsky served as the manager of the Operational Department of the Railways Administration of the Ministry of Railways from 1906, which at that time was then headed by K. S. Nemeshaev. Krieger-Voynovsky describes this period and his impressions of the service under Nemeshaev as follows: “I returned to my duties at the end of October, and two months later I received an urgent summon to St. Petersburg, where I was appointed to the post of manager of the Operational department of the Railway Administration. Besides purely technical, material, and legal issues, it was the most extensive and the most difficult department of the Ministry of Railways, and it was in charge, in fact, of all aspects of railway affairs on the entire network. It was especially difficult to organize the transportation of goods after the former strike, which affected employees and their discipline long after its end, and with the disorder that still continued throughout the Siberian railway due to the return of troops after the Japanese War. But I had excellent assistants in the person of D. N. Durnovo and A. A. Shebunevich and a number of skilled employees, with whom it was relatively easy to cope with the work. However, the work required our physical strength literally all day and night long, holidays and weekdays. During the first few months of my service in the Railway Administration, I was able to develop, bring through a number of interdepartmental meetings, and then, thanks to Nemeshaev's energy, legislate a very important measure to improve freight transportation, namely, the establishment of so-called District Committees to regulate mass cargo transportation. Until that time, no persons outside the Ministry of Railways had taken any part in these shipments, except for the transportation of mining goods in the Donetsk basin, where the distribution of wagons between the senders was carried out with the participation of industry representatives. The considerable estrangement of the Ministry of Railways and its local authorities, on the one hand, and the commercial and industrial organizations, on the other; almost complete ignorance of our merchants and industrialists of the railway apparatus, and the railway representatives of the main needs of the economic life of the country, the lack of transportation facilities during the period of increased grain exports and the lack of proper regulation of freight flows by the railways became the reason of constant complaints and misunderstandings

creating, in general, an unfavorable environment both for the work and development of our railway transport and ports, as well as for domestic industry and trade. It became absolutely necessary to bring together, mutually coordinate, and link the activities of railway institutions with the life of all those organizations and enterprises that were the main senders and recipients of transported goods. Since 1906 this general mutual work took place in the District Committees, where representatives of the railways, all local trade and industrial organizations, agricultural societies, zemstvos, cities and exchange committees participated. Since then, the district committees have played a very prominent role not only in the proper use of vehicles and the regulation of transportation, but also in the correct resolution of issues about the direction of new lines, the expedient strengthening and equipping existing roads, drawing up and changing various rules related to the transport of goods, tariff and other issues common to both railway transport and the interests of the economic life of the population. The first steps in the activities of this new institution required a lot of meetings, congresses, new correspondence, etc., but then this business was established quite quickly thanks to the efforts and concerns not only of my assistants mentioned above, but also of most of the committee chairmen, especially thanks to V. A. Gaevskii, M. A. Strizhevskii, A. G. Henrikhsen, I. N. Borisov, and A. V. Lukashevich." (Krieger-Voynovsky & Sproge, 1999, p. 22–24.)

The department entrusted to Nemeshaev was one of the fastest-growing in the Russian Empire at that time (Reichman, 1983). As of 1905, the number of employees of the railways of the Russian Empire reached 750,000 people. It should be mentioned that Nemeshaev was the Minister of Railways for a very short time (from October 28, 1905 to April 28, 1906). And very little information is available about his activities as the Minister.

On the website of the Ministry of Transport of the Russian Federation (Ministry of Transport of the Russian Federation), it is reported that during Nemeshaev's management of the Ministry of Railways, the Main Committee for the Protection of Railways was created and the Minister of Railways received the right to create local committees for the distribution of rolling stock for the transportation of bulk cargo of state-owned and private railways. Attempts were made to create syndicates of shipowners in river transport. There was a modernization of river and sea vessels. The development of projects for the development of the Northern Sea Route has begun.

Krieger-Voynovskii (Krieger-Voynovsky & Sproge, 1999, p. 53–54.) wrote the following about the K. S. Nemeshaev's activities as the Minister of Railways: "...Duke Khilkov at the end of 1905 was replaced by the Head of the Southwestern Railways, engineer Nemeshaev, who accepted a very heavy legacy since the railways were in poor condition because of the general discord that the 1905 revolution brought to the life of Russia, and the disorderly return of military units after the war with Japan. Despite this and the short period of his management of the department (for only 6 months), Nemeshaev without doubts significantly changed this somewhat stationary department and managed to carry out two significant reforms. The first was regrouping

state-owned railway lines between individual local administrations and merging them into larger groups, which was important in terms of improving the cost efficacy of their operations and speeding up freight traffic. The second was, as it was called, a kind of "constitution" in the regulation of freight traffic. According to it, District committees for the management of mass cargo transportation throughout the road network were organized with the involvement of a broad public. The regulation on these committees, requiring legislative sanction was carried out by Nemeshaev in a few days through the old State Council in its last session before the opening of the new legislative chambers; if this had not been done like this, it is likely that these committees would appear only in a few years."

Other scholars agree with Krieger-Voynovskii's conclusions. So, regarding the first conclusion, we find information that in 1905 the Law *On Measures to Attract Private Capital to the Railway Construction in Russia* was adopted (Pogrebinskii, p. 105). It provided new benefits for railway companies. In particular, the government's share of the profits of private companies was limited. They received the right to reimburse the treasury for the costs of improving the track facilities, building railway stations, various station buildings, etc. Among other benefits, railway companies were provided with government guarantees for the use of preferential tariffs for five years from the beginning of their activities, with monetary compensation for additional expenses. For example, this right was used by the Olonets Railway Company, which received compensation from the treasury for losses associated with the introduction of fixed tariffs, the difference between the ordinary commercial and preferential tariff (RSHA, F. 417. Op. 1. D. 33. L. 17). The government encouraged the formation of new private societies, but mainly in areas where large railway monopolies did not operate or new construction was not of interest to them. From 1905 to 1913, 23 new railway societies emerged (Pivovar, p. 151).

To understand the significance of the reform described by Krieger-Voynovskii in the second conclusion, it is necessary to consider the situation with the regulation of railway wagon fleets in the early 20th century in the Russian Empire. The need to regulate railway wagon fleets arose immediately with the commissioning of the first public railways and increased with the growth of traffic. The need for regulation was caused by the fact that as a result of the transportation of goods in some areas served by the railroad, an excess of wagons was formed, and in others, where loading was mainly carried out, their shortage was severe. Initially, the so-called closed regulation was used, which was carried out within the limits of the railroad, which had its own fleet of cars. At the junction points with other roads or waterways, the cargo was transshipped, and the empty wagons were sent to the place of the next loading. Wagons for loading were allocated by the station chief at the request of shippers. If there was a shortage of empty cars at this station, the applications were satisfied by the road traffic service according to the system of regulation of the car fleet. The constant requests of shippers served as the basis for planning and regulating transportation in the future. In case of a shortage of wagons on the road, the volume of loading was reduced or other

measures were taken in agreement with the committee of shippers. With the increase in the size of long-distance transportation, the shortcomings of the closed transport system became increasingly apparent, causing an excessive increase in wagon delays and the cost of transfer of goods at the junction points. These shortcomings were eliminated after the introduction of a direct non-unloading method of transportation under the condition of the urgent return of wagons to the owner road after unloading them. Violation of this condition caused huge penalties. The elimination of the overloading of goods at the junction points had a positive impact on the activities of the railways. However, an urgent return, usually of empty wagons, led to the fact that the following cargo was sent in other wagons.

Summing up this significant reform in the functioning of the system of cargo transportation by rail, sea and types of transport in the Russian Empire, Krieger-Voynovskii (Krieger-Voynovsky & Sproge, 1999, p. 35–36.) wrote the following lines: "Since the establishment of the District Committees for the Regulation of mass transportation in 1906, the situation with car fleets has only improved; significant mutual awareness and common work has been done to prepare and conduct "grain campaign" between grain merchants and railways, loading in different directions and to all ports was carried out systematically, depending on the carrying capacity of railway lines and the receiving capacity of ports, which eliminated the so-called traffic jams and delays in the way. But radical measures to improve this matter, namely, the arrangement of receiving elevators, the change of the General Charter of the Russian Railways, the law on the depersonalization of grain, the improvement of the equipment of ports, etc., were introduced shortly before the war, and this work is not over yet."

In 1906, the third edition of the fundamental *General Charter of the Russian Railways* was prepared, which was first approved on June 12, 1885 by Emperor Alexander III in the status of the law of the Russian Empire (Verblovskii, 1886, p. 5). Employees of the Ministry of Railways, headed by K. S. Nemeshaev participated in the work on the provisions of this document. It was approved in the form of the basic railway law establishing unified legal norms for the economic operation of Russian railway transport, which met the requirements of the developing capitalist economy of the country. The General Charter of the Russian Railways, which regulated the relationship between the owners of private railways, society, and the state, was in force until October 1917, and its main provisions on transportation activities until 1928 were in the railway charters of 1922 and 1927 (Testov, 2009). The influence of its norms on railway law-making is still felt today.

Regarding the development and construction of the railway network in the Russian Empire, the short period of management of the Ministry of Railways by K. S. Nemeshaev was difficult. The defeat of Russia in the 1905 war with Japan led to the isolation of most of the Chinese-Eastern Railway, as a result of which the remaining part of this road was in danger of being lost. There was a need to return to the idea of building the Amur Line. Continuous exploration of the route began under the K. S. Nemeshaev management of the Ministry of Railways in 1906 (Kraskovskiy &

Uyezdin, 1994a, p. 160). Geological exploration and mapping work allowed them to find the most rational and reliable option for the direction of the line.

There is also information that under the leadership of the Ministry of Railways by K. S. Nemeshaev, the exploration of ways to increase the capacity of the Trans-Siberian Railway continued (Kraskovskiy & Uyezdin, 1994b, p. 163). As of January 1, 1906, there were 12,480 km of double-track lines in Russia, 20% of the total length of the rail network across the country. At the same time, in most developed countries, the share of railways that had two or more tracks was much greater. For instance, in England it was 55%, 36.5% in France, and more than 35% in Germany. And only Italy and the United States had just over 15% of the multi-track lines. Second tracks in Russia were built only on those lines where the capacity exceeded 20–25 trains per day (in the first decade of the XX century it was the limit for single-track railways), as well as on lines where for some reason the construction of passing tracks was difficult. At that time, the increase in railway capacity was mainly due to their reconstruction by softening the longitudinal profile of the track, unifying and reducing the maximum gradients along individual sections, as well as the construction of additional passing tracks on the longest stretches. However, for intensive cargo lines, especially in the central regions of the country, these reconstruction measures were not always sufficient to accommodate the growing traffic, and then it was necessary to build the second main track without any changes to the route of the existing line. At the same time, the second track was laid on the same level as the first, repeating its geometric outlines in the plan. This did not cause difficulties, because during the construction on a single-track line, a double-track bed was laid. This approach to reconstruction became a tradition and was used until the beginning of the XX century until the issue of the construction of second tracks on the Trans-Siberian Railway raised. The situation there was different due to less favorable terrain features and mountainous areas. In addition, transportation has increased dramatically due to the intensive development of Siberia. It was necessary to shift from the traditional to the most radical ways to increase the capacity of the lines. The search for these methods attracted the attention of scientists and engineers. The issue of improving tracks, as the core of the railway, became urgent. But changing tracks is associated with great difficulties and requires deep feasibility studies since even a small reconstruction affects the entire complex of structures and devices of the railway and causes significant costs. In this regard, the construction of the second track on the Trans-Siberian Railway was preceded by a thorough engineering, economic and technical study of many issues, including field explorations. In contrast to the existing practice, the design and construction of the second tracks on the Trans-Siberian Railway were carried out simultaneously with the radical reconstruction of the existing lines, which was due to the rapid growth in traffic. This was the main peculiarity of the reconstruction activities on the Trans-Siberian Railway. In the studies carried out by N. P. Petrov, the economic feasibility of rebuilding the existing line simultaneously with the construction of the second track was determined based on the generally accepted principle at that time: the equality of

losses associated with the operation of the road along the existing route and the percentage of the invested capital for its correction (Kraskovskiy & Uyezdin, 1994c, pp. 166–169). Calculations were made for three levels of capacity: 16, 34 and 48 pairs of trains per day. At the same time, it was planned to increase the radii of the curves in order to increase the speed of trains. As a result, it was proved that even with the movement of 16 pairs of trains per day, it would be better to reconstruct the route, plan, and profile. Based on the calculations, it was considered necessary to reconstruct the existing line simultaneously with the construction of the second track on the Middle-Siberian Line. It was taken into account that of the 1240 km of the line to be reconstructed, 835 km were built in mountainous landscape and had a limiting grade of 17.4% on straight lines and 15% on curves with a radius of 320 m (Achinsk – Nizhneudinsk, Zima – Polovina); 355 km were built across foothills with a limiting grade of 11% on straight lines. Due to the fact that a successful location of the route was chosen for construction, it became possible to change the slopes without significantly lengthening the route by tracing individual sections with a significant degree of straightness. Of the 36 sections where the track was moved to a new location, 17 moves either did not have an extension or were shorter than the original ones. During the construction of the second track with the removal of the route of the existing railway track on the sections that require significant costs, they did not stop before re-routing and on the adjacent sections with a lighter and "quite profitable" profile in terms of operation. In addition, to remove the speed limits, the radii of the steep curves were increased from 256 m to 320 m and 426 m.

By that time Moscow had already been a major railway junction with high intensity of traffic flows. It was necessary to develop bypass and adjacent lines to Moscow with the arrangement of interchanges at different levels. In 1905–1906, work continued on the construction of the Moscow Belt Railway (Kraskovskiy & Uyezdin, 1994d, p. 190). The entire route was divided between contractors into 10 sections. The line was being built from 1903 to 1908 as a double-track line, with the intersection of adjacent railway lines at different levels. In addition to the overpass interchanges, four bridges were built across the Moskva River. The construction of the road cost 42 million rubles. The Moscow Encircle Railway with a length of 54 km was put into operation in 1908. It had exits to all 9 directions adjacent to Moscow, and, in addition, 24 access roads to enterprises and warehouses located on the periphery of the city.

The increased demand for freight transportation in 1905, particularly as a result of the Russian-Japanese war, required the introduction of more powerful steam locomotives than the "normal type" locomotives of the O^v series on the state-owned railway network (Figure 3).

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 (Proparovoz.ru). 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. 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, taking the SH class steam locomotive of the Chinese-Eastern and Vladikavkaz Railways as the basis for the project.

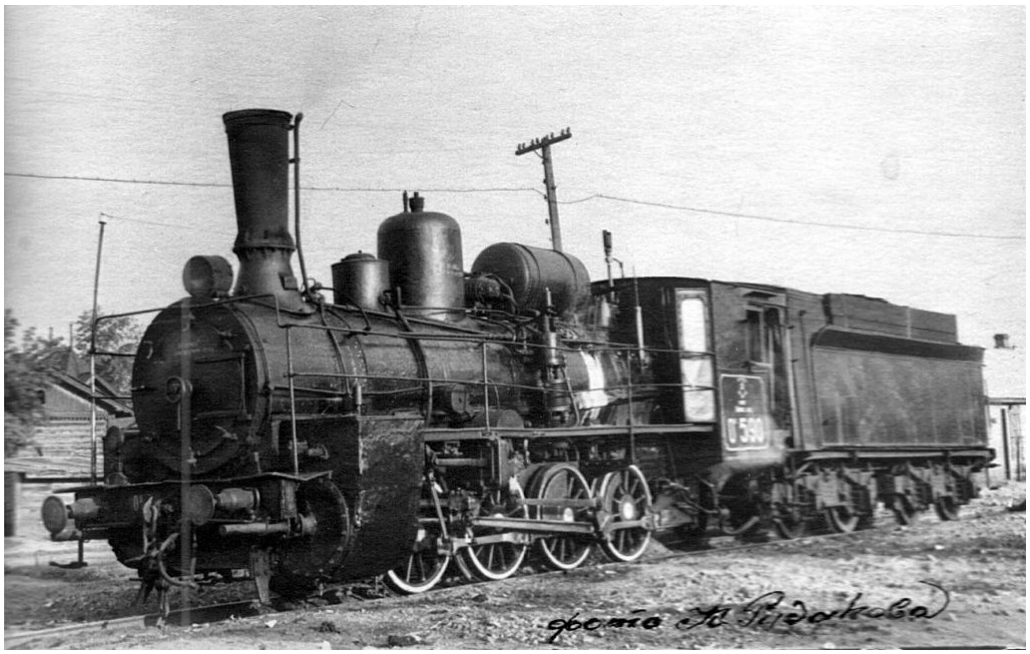

Figure 3. O[v] Series steam locomotive (Omsk steam locomotives) (Mib55 – Livejournal, 2013).

Figure 4. SHCH class steam locomotive. Steam locomotive series SHCH2067 (1931). Photo from the archive of A. A. Vasilyev-52. (TrainPix, 2017).

To gain experience of operating these locomotives on state-owned railways, 10 SH 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 A. S. Rayevsky in 1906 designed a freight steam locomotive with a two-cylinder machine compound type 1-4-0. In the technical documentation, the new locomotive was known as the "Chinese-Eastern Railway modified type 1-4-0" or "normal type 1905". 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. Compared with the SH class locomotives, the SHCH class locomotives were heavier, had higher steam pressure (14 kgf/cm^2 instead of 13 kgf/cm^2); block cylinders were replaced with stop cylinders, and piston spool valves were flat; the steam distribution mechanism, as in the O^V class locomotives, had a Gounod loop. In the draft design of the locomotive, the thickness of the steel sheets of the boiler drums was increased (from 17 to 17.5 mm) and the walls of the firebox were also slightly increased, as well as the frame and its mounting. The main dimensions of the machine, the diameter of the driving wheels and the grate area of the SHCH class steam locomotives (Figure 4) remained the same as those of the SH class steam locomotives. The maximum speed of the locomotive was set at 65 km/h. The SHCH class locomotives were produced by all the plants of the Russian Locomotive Building Society, and in 1911 by the Nikolaev Shipbuilding Plant. In total, 1910 locomotives of this series were built from private railways, and only the South-Eastern, Ryazan-Ural, and the North-Donetsk Railway, which was being built at that time (for the direction of Lgov – Osnova – Liman – Rodakovo – Likhaya), were ordered.

In 1906 while serving as the Minister of Railways, Nemeshaev took part in the preparation of the trip of the French scientist Paul Pelliot and the Russian officer Carl Gustav Mannerheim to China (Smirnov, 2012).

This trip is also known as the "Mannerheim's Asian Expedition". It was a reconnaissance expedition to the north and west of the Qing Empire, organized by the Russian General Staff and carried out by the Colonel of the Russian army, Baron Carl Gustav Mannerheim (Lobycin, 2006), between March 29, 1906 and December 21, 1908. The purpose of the expedition of Baron Mannerheim was directly related to the failures of Russia in the recent war with Japan. After traveling through the Chinese provinces, Colonel Mannerheim had to get acquainted with the Chinese preparation of the defense, the training of troops, find out how much the reforms of the central government of China affected its northern provinces, what is the intensity of their colonization by the Chinese, attitudes of the indigenous population of these places towards Russia and how much Japanese influence is noticeable in these places. He was also instructed to explore the route to the cities of Kashgar, Lanzhou, and then to Beijing "to study the conditions of movement for our cavalry". The military and

geographical objectives of the expedition were to describe the route from Kashgar to Uch-Turfan, as well as a military-statistical description of the Aksu oasis and the route to Kulja from there. It was also necessary to explore the valley of the Yulduza River. The last item of the extensive expedition task was "reconnaissance of the preparation of Lanzhou in terms of military". In addition, by the Finno-Ugric Society Mannerheim was commissioned to collect, if possible, archaeological and ethnographic collections for the National Museum of Finland, which was being created in Helsingfors. All these tasks were not set for all the participants of the expedition, which Colonel Mannerheim led, but actually for him solely, since the expedition, in addition to its chief, included two escort cossacks and several "hired people" from local residents, including an interpreter.

According to Smirnov (Smirnov, 2012, p. 28–36), P. Pellio was a very practical person and for his cooperation, he negotiated a whole set of benefits. To begin with, he demanded to supply him with a military convoy. This was promised to him on the condition that he would command the Cossacks only through the Russian officer Mannerheim, who was included in the expedition. In addition, P. Pellio demanded duty-free transportation of all the baggage of the expedition, which was approved by the Ministry of Finance (Foreign Policy Archive of the Russian Empire (FPARE), F. 148, op. 487, d. 190, l. 23). He also insisted on providing free 1st class travel to all members of the expedition across the Russian territory. This issue was agreed with the Minister of Railways K. S. Nemeshaev, who, in turn, was forced to turn to the emperor. Regarding the results of the meeting with the Emperor, the Minister informed V. N. Lamsdorff that "according to my [i.e., Nemeshaev's] most sincere report, on the 17th day of March this year, most graciously deigned to agree to the issuance of free tickets for the travel of members of the French expedition, ... as well as for the free transportation of their belongings weighing no more than 2500 kg from Libava to Andijan" (FPARE. F. 148, Op. 487, D. 190, L. 27).

Various social aspects related to the activities of employees and workers of railways were also important for K. S. Nemeshaev. This is evidenced by the following lines from the Order (Anonymous, 1906, February 20, p. 3): "The work of the railways is the achievement of the whole state and its population, as the continuous and correct movement of the rail network is the main factor in the economic and cultural life of the country". The words of the minister, which have not lost their significance even now, show that the Ministry of Railways, local road administrations and their leaders should strive to ensure, first of all, the solution of business problems, so the formation of corporate culture should be based on a system of relations between employees and workers regarding the conduct of official activities – first of all, ensuring the safety of locomotive traffic.

As the Minister, Nemeshaev did not forget about his trusteeship towards railway workers and their families. He tried his best to contribute to their development and the improvement of their life. The railway department reasonably believed that the development of the socio-cultural sphere affects the success of the implemented

activities. The war and the turbulent political events in the country in 1904–1906 had a negative impact on all educational institutions related to the railways. Since 1906, a period of stabilization of their work began. On January 13, 1906, K. S. Nemeshaev, the Minister of Railways, approved the new "Rules on Committees and Local Trustees for the Management of Educational Institutions on State-owned Railways" (Gordienko, 2013). This document expanded the authority of the higher agency for educational institutions in the field and led to the organization of the entire system, assigning the management to a special Committee under the management of each road and to local guardianship (Serdyuk, 2014, p. 97). On February 7, 1906 K. S. Nemeshaev approved Order No. 16 (State Archives of the Tomsk Region (SATR), F. 215. Op. 5. D. 11. L. 665, 666). In accordance with this Order, the Committee chaired by the head of the road, was entrusted with the welfare, material support, arrangement, proper development and improvement of the activities of the educational institutions of the road: general education and vocational schools, vocational courses for workers and technical and general education courses for other employees, libraries, museums, student dormitories, kindergartens, and other similar institutions. The local trustees, under the chairmanship of the trustee ("Honorary Guardian"), were charged with: supervision of educational institutions, expenses within the approved budget, the care of material support, the appointment and dismissal of employees, the permission to give them leave, etc. The heads of railway sections were usually appointed as Honorary guardians, who, in addition to their main duties, had to take care of all educational institutions located within the boundaries of their subordinate sections.

Another illustrative example of the social orientation of actions under the management of the Ministry by Nemeshaev is the establishment of the institute of sanitary doctors in railway transport. Due to the growing level of morbidity and mortality of the population in the medical railway environment, it was concluded that in order to successfully combat the spread of diseases, it is necessary to pay close attention to the problems of sanitation. In 1897, the post of inspector for the sanitary condition of railways of the Ministry of Railways was introduced (At'kov & Cfasman, pp. 127–128). Since the scope of the doctor's responsibilities for monitoring the implementation and compliance with sanitary standards was quite wide, in order to achieve these goals, doctors were required to create a separate category of medical personnel. At the Third Consultative Congress of Railway Doctors, the doctors came to a unanimous decision "to have sanitary doctors on the railways" (Mezavtsev, 1903, p. 212). This proposal was approved by the Ministry of Railways, which was headed by K. S. Nemeshaev, and in 1906, the Ministry of Transport of the Russian Federation. The Russian Railways Management Committee established the Institute of Sanitary Doctors (RSIA. F. 273. Op. 8. D. 123. L. 25). For their more effective work in the field, sanitary and hygienic laboratories were organized, and staff of paramedics-disinfectants was introduced. The introduction of the post of sanitary doctors and a special staff of lower medical workers, as well as the formation of a specialized sanitary and hygienic infrastructure, became the beginning of the formation of a system of

sanitary and epidemiological control on the railways. The sanitary doctor was appointed by the head of the road, the candidates for which were provided to him by the senior doctor. According to the objects, the control of the sanitary doctor extended to 1 – medical infrastructure, which included hospitals and emergency rooms; 2 – schools and dormitories; 3 – station and train buffets; 4 – rolling stock; 5 – a system for cleaning soil and water sources along the railway line; 6–apartments of workers and employees of the railway. All these institutions and buildings were in the area of attention of the sanitary doctor and were subject to regular inspections in order to identify and eliminate violations. When constructing new public buildings erected in the railway exclusion zone, it was necessary to obtain a doctor's opinion on the sanitary well-being of the structure (Shupikova, 2014).

At the turn of the XIX–XX centuries, two main approaches to the creation of a transit trade route from Siberia to Europe were identified: the supporters of the first approach proposed various options for connecting the Siberian river basins with the river systems of the Pechora, Northern Dvina, Volkhov, Ladoga and Neva by means of channels and/or rail tracks, in order to ensure the delivery of Siberian goods to the Baltic ports; the supporters of the second approach proposed to establish a connection between these rivers through the Kara Sea (Agapov, 2018). In 1898, the regime of duty-free trade on the Northern Sea Route was curtailed (only some goods were allowed to be carried at reduced rates) (Dolidovich, Fedorova, & Zhulaeva, 2019). Goods traffic with Europe via the Northern Sea Route has virtually ceased to exist. Until 1905, the government's policy towards Porto Franco at the mouth of the Siberian rivers did not change, which could not but affect the growth of political opposition to the local bourgeoisie. Among the Siberian merchants, there were people directly accusing the central government of one-sided economic policy, and ignoring the economic interests of the regions. S. V. Vostrotin, through the press, did not hesitate to blame the authorities for all the troubles of the Siberians: “Siberia owes its backwardness and the slow development of its cultural and economic life entirely to the Russian bureaucracy. Every initiative and attempt to raise the slow pace of Siberian life in any way, was ruined by the bureaucracy” (Vostrotin, 1906, p. 190). It is no accident that during the First Russian Revolution of 1905–1907, most of the Siberian bourgeoisie found themselves in the ranks of the Cadet Party, putting forward through its program the idea of liberalizing economic policy in regions, including Siberia. However, the events of the Russian-Japanese War became a much stronger factor that influenced the change in the position of the authorities on the issue of the Northern Sea Route. They showed that it is wrong to rely only on the Trans-Siberian Railway, without developing alternative logistics directions, because due to the increased flows of military purposes, a transport crisis has arisen. Under the pressure of the Ministry of Railways, in 1905 the government restored the port-franco regime in the mouths of the Siberian rivers, and also allocated 3 million rubles for the purchase of river vessels for organizing transportation along the Yenisei (Shilovskii, 2005). The rapid development of the colonization of Siberia, the growth of the Siberian efficient farming, and, not least, the

experience of the Russian-Japanese War required the early overcoming of the Siberian isolation (Agapov, 2018). At a Special meeting on the ways of communication in Siberia held in 1906 in Irkutsk, the old project of a single Siberian water highway from the Urals to the Pacific Ocean with a subsequent connection to the river network of European Russia was put forward. It was assumed that such a line could be built by 1920. At the same time, local entrepreneurs advocated the restoration of regular merchant shipping from Siberia to Europe via the Kara Sea (Baikalov, 1913, p. 2). Contemporaries noticed the transnational importance of all trans-Siberian transport routes, but first and foremost it was connected with the Northern Sea Route (Agapov, 2018). At the same time, after the Russo-Japanese War of 1904–1905, the Russian ruling circles increasingly saw it as a national communication system that had not only economic, but also military-strategic importance. Before the First World War, the idea of the Northern Sea Route as an international line, which was typical for the end of the XIX century, was replaced by the idea of it being a kind of "natural monopoly" of the Russian state.

It should be mentioned that the revolutionary events of 1905 and the tense political situation in the Russian Empire of those years did not allow a statesman of such magnitude as the Minister of Railways to remain politically neutral for a long time. Nemeshaev's political views were rather liberal. Gurko in his book (Gurko, 2000, p. 469.) describes it this way: "...at the beginning of November, the state Comptroller D. A. Filosofov and the Minister of Railways K. S. Nemeshaev spoke in favor of the introduction of common suffrage. It was only thanks to Witte's intervention that these heads of departments abandoned such radical demands." The data on Nemeshaev's loyalty is confirmed by his telegram to all railways of December 5, 1905, forbidding employees to join communities for the purpose of organizing strikes (State Archives of the Tomsk Region (SATR). F. 215. Op. 1. D. 257. L. 126).

However, the very position of the Minister of Railways obliged to act defending the interests of the state first and above all. Defending the need for firm and decisive measures to end the strike on the railways (up to the dismissal of civil servants involved in the protest actions), the Minister of Railways K. S. Nemeshaev believed that without such measures it was "impossible to fully implement the principles of the manifesto of October 17" (Novoselsky, 2020, p. 338.). Thus, at the turn of 1905–1906 the "reaction first, reform next" became the leading principle in the government policy, and the leading role in its implementation was played by P. N. Durnovo. On December 16, 1905, the Minister of Internal Affairs appealed to all governors and mayors to dismiss zemstvo and city employees (especially doctors, teachers, and statisticians) without waiting for cases to be brought against them, if they were engaged in illegal agitation."

Confirmation of Nemeshaev's consistency in his attitude to the strike movement is a note in The Railroader journal (Anonymous, 1906, April 13). It says that "...when the railway voters were ready to leave the house to go to the place where the elections were held, they were stopped. Dispatch No. 497 "To Protect the Kursk-Kharkiv-Sevastopol Railway in court" of March 6 signed by Schaufus with Nemeshaev's order

was received. It said that "the law does not give employees the right to interrupt the performance of their duties to participate in elections and they can participate in elections only in their free time."

K. S. Nemeshaev believed that the main reason for the strike movement on the railways of the Russian Empire in 1905 had been the low level of culture of relations between managers and subordinates on the railway lines. In his Order of February 9, 1906, he wrote (Anonymous, 1906, February 20, p. 3): "After going there and getting acquainted with the conditions under which these strikes of 1905 arose and took place and having ascertained the reasons why on some roads external propaganda was completely ineffective, and on others, it was easily spread, I came to the conclusion that this must be largely explained by the mutual relations that existed between the junior and senior railway employees and, undoubtedly, depended on the views and beliefs of the higher rank employees on the road and on the degree of moral authority that the immediate superiors had in the eyes of the lower railway agents. Where the superiors were conscious of their official duty and were close to their subordinates, knew their needs and, along with strict demands for the performance of their official duties, showed reasonable care for the possible improvement of their working and living conditions, these relations were normal and were based on mutual trust and respect. If correct relations were built and existed for a long time, they have become traditions. Most employees clearly understood their duties to the people and the state, and external factors and agitation did not succeed at all, or the strike movement, breaking out in individual points, was immediately stopped. As it was personally evidenced, on the roads where the strikes were particularly widespread, either a strictly utilitarian attitude towards lower-level employees or a formalism that excluded the possibility of live communication prevailed. On these roads, the junior employees were left to themselves, easily succumbed to any outside influence; the superiors, not having the authority and trust among their subordinates, could not exert any influence on them [...]. At the same time, there are numerous examples when, at certain railway stations that went on strike in December, the lower employees, thanks to the reasonable and sobering influence of their immediate supervisor, refused to join the strikes and continued their work. It proves the importance of the moral authority of individuals and the possibility of strengthening a clear understanding of the lower railway personnel's official duty.

Witte and his government were dismissed on April 22, 1906. Witte wrote about his own resignation and the resignation of his Council of Ministers (Witte, 2010, pp. 922–924): "I heard almost every day from people who were to some extend loyal to me or sympathizing with me that the emperor was constantly being served, mostly through General Trepov, with denunciations and various notes, and, as the calm went on and cowardice decreased, these notes had more and more weight at the court. In January, the Minister of Railways made an inspection trip across the railways, and when he returned to St. Petersburg, he told me that there was a note circulating across Russia for the signature by large landowners. It made charges against Kutler, the

Minister of Finance Shipov (who was absolutely right in his convictions, but certainly not a black-hundredist), Putilov (his deputy, the manager of a Noble and Peasant Bank) with revolutionary designs, and a demand for a change of my ministry. At this time, my relations with His Majesty were already strained to the extreme, and I remained in my post only out of loyalty to the monarchical principle; all this will be clearer if I manage to finish these sketches. But what my relations really were, is evident from the following letter, which I have saved as a copy of what I wrote to the emperor: "I have the honor to present to your Imperial Majesty a petition (which can be found in my archives), which goes through the hands of landowners to collect signatures. It is printed in Kyiv, although the initiative for its appearance, definitely, comes from St. Petersburg. I had been informed of the intentions of this petition a few weeks ago, and now it was handed to me by K. S. Nemeshaev, who had come from the south. Of course, I could find out about its authors and its initiators, but I consider it as a waste of time matter, especially since I, like everyone living in public, know that the initiative of this case comes from the so-called "Black Hundred of the State Council". And then the fruitful thought of such a petition belongs to Count A. P. Ignatiev, Stishinsky, or Sturmer, or Goremykin, or Abaza, which I do not care at all. However, I think that this respectable company does not seek to become in power, because they do not want to put their own persons in the game, and therefore they prefer to act and spread all sorts of lies from behind the bushes in St. Petersburg drawing rooms and through the press devoted to them."

Conclusions.

The systematization and analysis of historical data made it possible to recreate the historical picture of the activities of Klavdii Semyonovich Nemeshaev as Minister of Railways of the Russian Empire.

We consider the establishment in 1906 of central, local and district committees for the regulation of mass transportation of goods to be one of the most important achievements of Nemeshaev as Minister of Railways. These committees were given the right to send wagons from the railways that had a surplus of them to the railways that needed them. This was the first centralized measure to regulate the car fleet, but it was mandatory for state-owned roads, and as a recommendation for private ones.

The legislative policy of the Ministry of Railways, under the leadership of K. S. Nemeshaev has been considered.

The article dwells on K. S. Nemeshaev's contribution in the development and creation of a new type of freight locomotive for state-owned railways.

The social policy of the Ministry of Railways, during the leadership of K. S. Nemeshaev, has been analyzed. The successes in streamlining and establishing the work of railway educational institutions and sanitary railway inspectors have been noted.

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Аналіз діяльності Клавдія Семеновича Немішаєва на посаді Міністра шляхів сполучення Російської імперії

Анотація. *Стаття продовжує цикл статей авторів, присвячений оцінці діяльності керівників Міністерства шляхів сполучення Російської імперії. У даній статті автори зробили спробу систематизувати та проаналізувати історичні дані про діяльність Клавдія Семеновича Немішаєва на посаді Міністра шляхів сполучення Російської імперії. На відміну від численних біографічних досліджень, присвячених К. С. Немішаєву, про його діяльність на посаді міністра відомостей мало, і вони до сих пір носили розрізнений і не систематизований характер. Аналіз архівних матеріалів, наукових публікацій, мемуарів сучасників і колег Немішаєва, дозволили провести детальну оцінку його діяльності і політики управління міністерством. Показано, що незважаючи на короткий термін керівництвом відомством, послідовна політика Немішаєва і великий досвід роботи на керівних посадах, дозволили йому в стислі терміни провести дві значні реформи. Перша полягала в перегрупуванні казенних залізничних ліній між окремими місцевими управліннями та об'єднанні їх в більш великі групи, що мало важливе значення як для поліпшення і здешевлення їх експлуатації, так і для прискорення товарного руху. Ще одним з найважливіших досягнень Немішаєва на посаді Міністра шляхів сполучення, автори даної статті вважають створення в 1906 році центральних, місцевих та порайонних комітетів з регулювання масових перевезень вантажів. Це була перша централізована міра з регулювання вагонного парку. Великий управлінський досвід, висока ерудованість і енергійність Немішаєва, обумовлювали також окремі успіхи на інших напрямках роботи ввіреного йому відомства. Були спроби створення синдикатів судновласників на річковому транспорті. Відбувалася модернізація річкових і морських судів. Почалася розробка проектів освоєння Північного морського шляху. Дана оцінка розвитку і будівництва мережі залізниць в Російській імперії, під час керування міністерством Немішаєва, зокрема Амурської лінії і Московської окружної залізниці, збільшення пропускної здатності Транссибу. Показано, що далеко не на останньому місці для*

К. С. Немішаєва були різні соціальні аспекти, що стосуються діяльності службовців залізниць. Також в статті розглянута законотворча політика Міністерства шляхів сполучення тих років. Розглянуто участь Немішаєве в підготовці подорожі французького вченого Поля Пеллі і російського офіцера Карла Густава Маннергейма в Китай. У зв'язку з масовою заміною на казенних залізницях легких і зношених рейок важчими, і необхідністю списання з інвентарю значної кількості паровозів споруди 1850-х і 1860-х років, доцільно було ввести паровози більш потужного типу. Показаний внесок К. С. Немішаєва в розвиток техніки і створення нового типу товарного паровоза для казенних залізниць. Дана оцінка політичними поглядами Немішаєва.

Ключові слова: *транспорт Російської імперії; залізниця; реформи; Сергій Юлійович Вітте; Рада міністрів; паровоз серії Щ*

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Анализ деятельности Клавдия Семеновича Немешаева на посту Министра путей сообщения Российской империи

Аннотация. *Статья продолжает цикл статей авторов, посвященный оценке деятельности руководителей Министерства путей сообщения Российской империи. В данной статье авторы сделали попытку систематизировать и проанализировать исторические данные о деятельности Клавдия Семеновича Немешаева на посту Министра путей сообщения Российской империи. В отличие от многочисленных биографических исследований, посвященных К. С. Немешаеву, о его деятельности на посту министра сведений мало, и они до сих пор носили разрозненный и не систематизированный характер. Анализ архивных материалов, научных публикаций, мемуаров современников и коллег Немешаева, позволили провести детальную оценку его деятельности и политики управления министерством. Показано, что несмотря на короткий срок руководством ведомством, последовательная политика Немешаева и большой опыт руководящей работы, позволили ему в сжатые сроки провести две значительные реформы. Первая заключалась в перегруппировке казенных железнодорожных линий между отдельными местными управлениями и объединении их в более крупные группы, что имело важное значение как для улучшения и удешевления их эксплуатации, так и для ускорения товарного движения. Еще одним из важнейших достижений Немешаева на посту Министра путей сообщения, авторы данной статьи считают учреждение в 1906 году центральных, местных и порайонных*

комитетов по регулированию массовых перевозок грузов. Это была первая централизованная мера по регулированию вагонного парка. Большой управленческий опыт, высокая эрудированность и энергичность Немешаева, обуславливали также отдельные успехи на других направлениях работы вверенного ему ведомства. Предпринимались попытки создания синдикатов судовладельцев на речном транспорте. Происходила модернизация речных и морских судов. Началась разработка проектов освоения Северного морского пути. Дана оценка развития и строительства сети железных дорог в Российской империи, во время управления министерством Немешаева, в частности Амурской линии и Московской окружной железной дороги, увеличения пропускной способности Транссиба. Показано, что далеко не на последнем месте для К. С. Немешаева были различные социальные аспекты, касающиеся деятельности служащих железных дорог. Также в статье рассмотрена законотворческая политика Министерства путей сообщения тех лет. Рассмотрено участие Немешаева в подготовке путешествия французского ученого Поля Пеллио и российского офицера Карла Густава Маннергейма в Китай. В связи с массовой заменой на казенных железных дорогах легких и износившихся рельсов более тяжелыми и необходимостью списания с инвентаря значительного количества паровозов постройки 1850-х и 1860-х годов целесообразно было ввести паровозы более мощного типа. Показан вклад К. С. Немешаева в развитие техники и создание нового типа товарного паровоза для казенных железных дорог. Дана оценка политическим взглядам Немешаева.

Ключевые слова: *транспорт Российской империи; железная дорога; реформы; Сергей Юльевич Витте; Совет министров; паровоз серии Щ*

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