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HISTORIOGRAFIA POWSTAWANIA I ROZWOJU TEORETYCZNEJ ELEKTROTECHNIKI NA UKRAINIE (XX W. - POCZĄTEK XXI W.)

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Adnotacja. Artykuł poświęcono określeniu poziomu rozwoju naukowego powstawania i rozwoju teoretycznej elektrotechniki na Ukrainie w XX w. – początku XX w. Autor przeprowadził kompleksową analizę historiograficzną publikacji dotyczących powstawania tego kierunku na Ukrainie, wyróżniono dwa okresy chronologiczne: okres epoki radzieckiej (1930-1991) i okres nowożytny (po 1991). Wśród pism historycznych okresu sowieckiego wyróżniono prace dotyczące historii fizyki i rozwoju teorii elektryczności i magnetyzmu, prace opisujące powstawanie edukacji elektrotechnicznej na Ukrainie i powstanie naukowego kierunku elektrotechnicznego. Drugi okres badań historiograficznych charakteryzuje się znacznym wzrostem publikacji, pojawieniem się różnorodnych prac na temat historii elektrotechniki teoretycznej, wyższej szkoły elektrotechnicznej, sektora przemysłu elektrotechnicznego, dużej liczby biografistyki naukowej. Tak więc kompleksowe badanie historiograficzne kompleksowo oświetliło kierunki poszukiwań naukowych i stworzyło hierarchiczną strukturę naukowej pracy historycznej, a stopniowa analiza literatury pozwoliła odkryć i rozpowszechnić informacje o tworzeniu i rozwoju teoretycznej elektrotechniki, jako podstawowego kierunku elektrycznego na Ukrainie.

Słowa kluczowe: badania historiograficzne, fizyka, elektryczność i magnetyzm, teoretyczne podstawy elektrotechniki, szkoły naukowe, biografistyka naukowa, Ukraina.

THE HISTORIOGRAPHY OF FORMATION AND DEVELOPMENT OF THEORETICAL ELECTRICAL ENGINEERING IN UKRAINE (XX – EARLY XXI CENTURY)

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Abstract. The article is devoted to the coverage of the level of scientific elaboration of formation and development of theoretical electrical engineering in Ukraine in the 20th – beginning of the 21st centuries. The author has conducted a comprehensive historiographical analysis of the numerous publications on the formation of this direction in Ukraine and has identified two chronological periods: Soviet era (1930–1991) and modern period (after 1991). Each of these periods have its own characteristics that influenced the collection of scientific literature. Therefore, the complex historiographical research has comprehensively highlighted the directions of scientific investigation and formed the hierarchical structure of the scientific historical work, and the gradual analysis of the literature helped to reveal and distribute the information on the formation and development of theoretical electrical engineering as the basic direction of electrical engineering in Ukraine.

Key words: historiographical studies, physics, electrical engineering and magnetism, theoretical basics of electrical engineering, scientific schools, scientific biography, Ukraine.

ІСТОРІОГРАФІЯ СТАНОВЛЕННЯ ТА РОЗВИТКУ ТЕОРЕТИЧНОЇ ЕЛЕКТРОТЕХНІКИ В УКРАЇНІ (XX СТ. – ПОЧАТОК XXI СТ.)

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Анотація. Стаття присвячена висвітленню рівня наукової розробленості становлення та розвитку теоретичної електротехніки в Україні у XX ст. – на початку XX ст. Автором проведено комплексний історіографічний аналіз публікацій стосовно становлення цього напряму в Україні, виокремлено два хронологічні періоди: період радянської доби (1930–1991 рр.) та сучасний період (після 1991 р.). Серед історичних праць радянського періоду

виокремлено праці з історії фізики та розвитку теорії електрики і магнетизму, праці, які описують формування електротехнічної освіти в Україні та становлення наукового електротехнічного напряму. Другий період історіографічних досліджень характеризується значним збільшенням публікацій, появою різнопланових праць з історії теоретичної електротехніки, вищої електротехнічної школи, галузевого сектору електротехнічної науки, великою кількістю наукової біографістики. Отже, комплексне історіографічне дослідження всебічно висвітлило напрями наукового пошуку та сформувало ієрархічну структуру наукової історичної роботи, а поступовий аналіз літератури дав змогу розкрити та поширити відомості щодо формування та розвитку теоретичної електротехніки як базового електротехнічного напряму в Україні.

Ключові слова: історіографічні дослідження, фізика, електрика і магнетизм, теоретичні основи електротехніки, наукові школи, наукова біографістика, Україна.

Main part. The science has always been a determining factor in the country's scientific and technological progress and its effective economic development. Modernization of the contemporary society without the development of science becomes impossible. The tasks of European integration of Ukrainian science, involvement of scientists in expert and educational processes, and international technology transfer are the first and foremost in the general process of modernization of the domestic scientific sphere. Electrical engineering is not an exception; producing and disseminating knowledge is becoming the basis for the creation and improvement of new energy sources, a variety of electrical products for the production, conversion, transmission and consumption of electricity. Electrical engineering is one of the most developed industrial branches, providing products for space, medical, industrial, transport, agrarian and domestic spheres of human activity. It is necessary to take into account, that the increase of manufacture of electrotechnical production is impossible without introduction of modern high technologies and in this connection, while reforming of branch science, we should keep experience and scientific groundwork of the past to create conditions for development of electrotechnical science in the future.

On this basis, the historical research and rethinking of the development of the theoretical basis of electrical engineering direction – theoretical fundamentals of electrical engineering (TFE) – is actualized. The formation of this direction in Ukraine was important for the development of special technical education and was connected with the creation of specialized departments of electrical engineering in higher technical educational institutions. The scientific and intellectual potential, necessary equipment and facilities were concentrated at the departments and this contributed to the development of the theoretical basis of electrical processes and technologies. The direction of theoretical electrical engineering was organically connected with the creation of a training system of engineering and scientific personnel, which was needed by the electrical industry. The theoretical researches in the field of electrical engineering became more systematic with the establishment of the Institute of Electrical Engineering of the Ukrainian SSR Academy of Sciences in the 1940s, the basic directions of the scientific subjects of its departments were the theoretical foundations of power engineering and electrical engineering. The scale of theoretical works carried out at the institute determined the training of scientific personnel in this direction.

Aim of the article. The aim of the article is the historiographical analysis of the available publications concerning the formation and development of theoretical electrical engineering in Ukraine, and the absence of generalizing works on this question in the Ukrainian historical science increases its urgency.

A comprehensive historiographical study of the available literature on the formation and development of theoretical electrical engineering in Ukraine made it possible to distinguish two chronological periods: the period of the Soviet era (1930–1991) and the modern historical period (after 1991). Each of these periods have its own characteristics that influenced on the selection of scientific material. Proceeding from thematic and problematic principle, the amount of scientific literature in each period has been divided into groups, which have different content.

Among the historical works of the first period the following groups are distinguished: 1) the general investigations on the history of physics and development of electrical engineering and magnetism theory against the background of the world progress and biographical materials highlighting the activities of electrical engineering scientists; 2) the formation of electrical engineering as a science in Ukraine; 3) the works concerning the formation of electrical engineering education. The initial stage in the formation of electrical engineering is often described as the formation of a separate branch of physics – the theory of electrical engineering and magnetism. The amount of scientific literature on the history of physics made it possible to trace the formation of the physical foundations of theoretical electrical engineering. One of the first works to summarise the history of physics was the work by the well-known theoretical physicist O.D. Khvolson (Khvolson, 1932). In this work, the author revealed the main achievements in physics in the early 1930s, including those in the field of electrical engineering and magnetism. The publication of the outstanding electrical engineer V.F. Mitkevich "Faraday's works and modern development of electrical energy applications" helps to clarify the influence of the theory of the famous English physicist on the formation of the modern theoretical foundations of electrical engineering science (Mitkevich, 1932).

The initial stage of development of electrical engineering is devoted to the work of V.I. Lebedev "Electrical Engineering, Magnetism, Electrical Engineering Science in its Historical Development", where the author conducted a thorough analysis of the formation of knowledge about electricity and magnetism, gave a complete description of the stages of formation of the theory of electricity since ancient times, discovered the history of the first treatises on electricity and magnetism, the theory of atmospheric electrical engineering and the formation of the experimental and theoretical foundations of electrical engineering (Lebedev, 1937).

The historiography of this period is supplemented by B.G. Kuznetsov's work on general issues of electrical engineering and power engineering, in which the author described the history of the electrical industry in connection

with the rapid development of the USSR power complex in the early 1930s, and a separate place was also given to the development of the theoretical foundations of electrical engineering (Kuznetsov, 1937).

It is also possible to single out the publication in 3 parts of the collective of authors of the Moscow Power Engineering Institute under the general supervision of L.D. Belkind. In the second part, the authors covered the development of electrical engineering both as a technical branch and as a scientific trend, processed and systematized a large layer of factual material, which reflected the historical course of research in different fields of electrical engineering, highlighted contributions of certain scientists, scientific schools and organizations in research on certain issues of electrical engineering (Belkind, 1957). The authors reviewed the history of theoretical electrotechnics and analyzed the historical stages of this branch of science and its connection to physics, mathematics, radio engineering, oscillation theory and others. This work presents the history of electrical engineering in the Soviet Union in the first half of the twentieth century in a complete and comprehensive way.

Among the works devoted directly to theoretical electrical engineering it is necessary to single out O.D. Simonenko's monograph "Electrical Engineering Science in the First Half of the Twentieth Century" (Simonenko, 1988). The author considered regularities of formation of the electrical engineering science and proposed a periodization of its development, based on methodological approaches to the study of technical sciences. And in the fifth section of O.D. Simonenko's work it was investigated the problem of electrical engineering practice and directions of theoretical research, and revealed the development of the theoretical foundations of electrical engineering as a fundamental scientific and a basic academic discipline.

A separate group of historiographies of the Soviet period consists of publications on the anniversaries of famous electrical engineering scientists or outstanding discoveries and inventions in the "Electrical Engineering" the oldest periodical journal of electrical engineering. These are the works of M.I. Radovsky (Radovsky, 1939: 59–61), N.A. Shostin (Shostin, 1940: 54–59), I.G. Klyatzkin (Klyatzkin, 1957: 70–73), L.D. Belkind (Belkind, 1965; 1967: 83), in which the authors provided brief biographical data of scientists and inventors, revealed their contribution to the development of electrical engineering research, and provided valuable bibliographic information.

To the historiography of the second thematic group the works concerning the issues of formation of electrical engineering as a scientific direction in Ukraine are involved. One group of works consists of the publications devoted to the anniversary of electrotechnical events, in which against the background of a comprehensive review of the development of electrotechnical direction in the USSR there is enough material about the development of Ukrainian electrotechnical centres, the formation of individual scientific schools and directions and biographical information of some representatives of the Ukrainian scientific community. Thus, in the publication of V.A. Venikov, B.A. Knyazevsky, and V.I. Sokolov "The Contribution of the Soviet Higher Electrical Engineering School to Scientific Research in Electrical Engineering and Power Engineering for 50 Years" the scientific electrical engineering schools of technical educational institutions of Ukraine are partially characterized (Venikov, Knyazevsky, Sokolov, 1967: 1–15).

The publication of K.S. Demirchyan and A.V. Netushil "The Development of Theoretical Foundations of Electrical Engineering for 60 Years of Soviet Power" deserves special attention, in which the authors highlighted the development of theoretical electrical engineering based on the internal differences of its basic sections – the theory of electric circuits and electromagnetic field theory (Demirchyan, Netushil, 1977: 3–11). Considerable attention is paid to the scientific heritage of scientists from Kiev, Kharkiv, Odesa and Lviv technical institutes and the contribution of young scientists electrotechnicians from Kharkiv Electrotechnical Institute (KhEI) such as A.N. Efros and A.N. Danilevsky in the development and application of the operational method of transient processes calculation in the study of the special division of the theoretical fundamentals of electrical engineering (TFE) course is covered in detail.

Almost the only work where the attempt of a comprehensive analysis of the formation of theoretical electrical engineering in Ukraine was carried out and the formation of its separate divisions and new research directions of Ukrainian scientists was highlighted is "From the History of Formation and Development of Theoretical Foundations of Electrical Engineering in Ukraine" publication of A.N. Milyakh and S.I. Kirpatovskiy (Milyakh, Kirpatovskiy, 1967: 3–15). In the publication "The Development of Electrical Science in Ukraine" authors investigated more deeply the role of scientific schools in the development of special theory and directions of theoretical electrical engineering in the second half of the twentieth century in Ukraine (Milyakh, Chizhenko, Shidlovskiy, 1980: 13–24).

Some aspects of the significant contribution of Ukrainian scientists to the development of scientific ideas in the USSR are presented in the work of K.K. Khrenov, where the author highlighted the leaders of scientific schools, emphasized the contribution of scientific centres of development of general electrical theory (Khrenov, 1954: 3–13).

Multiple works on the issues of the formation of electrical engineering education are allocated to the last group. It includes a number of works on the history of higher technical educational institutions and academic institutions. V.M. Khrushchev's publication is interesting in historical terms concerning the work of KhPI during the first decade of its existence, the selection of scientific schools and the formation of young electrical elite under the guidance of experienced scientists-innovators of the first electrotechnical educational institution (Khrushchev, 1941: 25–31).

The essay on the history of the Odesa Polytechnic Institute across fifty years made it possible to trace the formation of a specialized department of electrical engineering, its influence on the development of research work at the institute, and also highlighted the individual chapters of the work of L.I. Mandelstam, N.D. Papaleksi and B.F. Tsomakion, prominent scientists at the Institute (Tsymbal, Nikulin, 1968).

The publications of L.A. Bessonov (Bessonov, 1963: 83–85), O.B. Bron (Bron, 1964: 88–89) and S.V. Strakhov (Strakhov, 1964: 86–87), devoted to an extended discussion concerning the content and methodological basis

of teaching the basic theoretical discipline were useful for understanding the place of TFE discipline in the system of electrical engineering training and the formation of a number of related disciplines.

The second chronological period of development of historiographical research is characterized by a significant increase in publications, the uprise of various works on the history of general electrical engineering, higher electrical engineering school, the branch of electrical engineering, as well as a large number of scientific biographies. This period includes: 1) the publications on the history of formation and development of scientific areas, individual scientific ideas and problems of theoretical electrical engineering; 2) the works devoted to the coverage of the activities of specialized research institutions, technical universities and branch institutions in Ukraine; 3) the scientific biography.

Also, in the second historiographical period the number of generalizing works on the history of physics, electrical engineering and energy increases considerably. Among the array of scientific literature, it is necessary to highlight the scientific achievements of Yu.O. Khramov on the history of physics. These are studies on the history of physics (Khramov, 2012), the history of prominent personalities, Ukrainian scientific schools in the field of physics (Khramov, 1991), as well as the methodological issues of the development of physical disciplines (Khramov, 2017).

Among the works on the history of electrical engineering, "The History of Electrical Engineering" fundamental collective monograph under the general editorship of I.O. Glebov deserves special attention, where the authors conducted a thorough analysis of the development of various areas of electrical engineering, among which a prominent place is given to the direction of theoretical electrical engineering and the contribution of the Ukrainian scientific community in its formation and the development in the USSR (Glebov, 1999).

The development of theoretical electrical engineering in Ukraine has been comprehensively studied in the works of Professor of NTU "KhPI" O.E. Tverytnykova. The monograph "The Origin and Development of Scientific and Technical School of Electrical Engineering of Professor P.P. Kopnyaev (1885–1950)" focuses on the fruitful work of a prominent scientist in the creation of electrical engineering at the Kharkiv Institute of Technology (KhIT) and the introduction of the higher electrical education in Ukraine (Tverytnykova, 2010). The prominent place in the historiographical complex belongs to "The Electrical Industry of Ukraine in the Second Half of The Twentieth Century: Directions of Development and Achievements" another monograph of this scientist, which outlines the development of electrical measurements, electric machines, power engineering and theoretical electrical engineering in Ukraine (Tverytnykova, 2017).

"The Beginning of Physical and Electrical Engineering Research at Lviv Polytechnic" publication of A.Y. Vorobkevych, O.M. Rokitsky and V.A. Shenderovsky significantly complements historiography with the information about the development of physics and theoretical electrical engineering in the oldest technical institution in Ukraine (Vorobkevych, Rokitsky, Shenderovsky, 2003: 17–21).

The achievements of the Higher School of Electrical Engineering and the development of the theoretical foundations of electrical engineering at the Kyiv Polytechnic Institute (KPI) are outlined in the work of N.R. Slobodyan, N.V. Trofimova, V.I. Chibelis "On the History of the Department of Theoretical Foundations of Electrical Engineering of KPI" (Slobodyan, Trofimova, 2011: 2–11). In the next scientific work, the authors characterize the prerequisites for the theoretical foundations of electrical engineering in Ukraine, reveal the process of formation of theoretical electrical engineering as an independent scientific discipline in KhIT and KPI in the late 19 – early 20 centuries (Slobodyan, Trofimova, Chibelis, 2014: 43–47).

The separate group consists of historiographical works on the history of scientific institutions and educational institutions. The works by Academician A.K. Shydlovsky became valuable for clarifying the place of the Institute of Electrical Engineering in the formation of fundamental research on the theoretical basis of electrical engineering, "Institute of Electrodynamics of the National Academy of Sciences of Ukraine. History, Achievements, Prospects" (Shydlovsky, 1997: 3–11) and "Turning the Pages of History" (Shydlovsky, 2007: 3–10), which are devoted to the historical achievements of the leading electrical engineering institute of Ukraine. In the works the author outlines the main stages of the development of the institute, provides biographical information of leading scientists, directors of the institute and outstanding scientists.

Also, the considerable attention is paid to "The Research on Theoretical Electrical Engineering at the Departments of the Institute of Electrodynamics of the NASU of Ukraine" publication of N.A. Shydlovska (Shydlovska, 2007: 20–25), which is directly devoted to the analysis of institute scientists in the field of theoretical electrical engineering and coverage of scientific developments of each department.

The stages of the Institute of Technical Problems of Magnetism of the National Academy of Sciences of Ukraine formation are described in the anniversary publication of V.Y. Rozov "To the 40th Anniversary of the Scientific and Technical Centre of Magnetism of Technical Facilities of the NASU of Ukraine. History, Achievements, Prospects" (Rozov, 2010: 74–80).

In the collective monograph "Kyiv Polytechnic Institute. Essay of History" the authors cover the history of one of the oldest technical educational institutions of Ukraine, its structure, the main stages of formation and development, the activities of leading scientific schools and areas, including the scientific school of the Department of TFE on power conversion technology of Academician I.M. Chizhenko (Belyakov, Vasylenko, Vilkov, 1995).

P.H. Stakhiv's anniversary work "The Origins and Development of Electrical Education and Science at Lviv Polytechnic (1891–2016)" on the history of electrotechnical education at the oldest Ukrainian polytechnic institution gives a complete, detailed analysis of the development of electrical education and science at the institution,

highlights the initial stage of formation of the institute's electrical scientific school, a separate chapter of the monograph is devoted to the history of the development of the Institute's department of theoretical and general electrical engineering (Stakhov, 2018).

The publications on the anniversary dates of faculties and departments proved to be important for the study. In particular, in the essay by KPI scientists "To the 100th anniversary of the Faculty of Electrical Engineering and Automation: M.A. Artemyev – the Founder of Electrical Engineering School in Kyiv Polytechnic" the authors outline the role of the professor M.A. Artemyev in the establishment of electrical engineering science and education in KPI (Spynul, Galushko, Gryshko: 2018). The publication of KhPI scientists "The Department of Theoretical Foundations of Electrical Engineering has been functioning for 80 years in KhPI" reveals the main stages of the department's development, gives a description of the scientific search, and describes the initial stage of forming a cycle of new electrical engineering disciplines developed by the department's teachers in the 1990s (Borysenko, Samsonov, Rezynkin, Tverytnykova, 2011).

A distinctive large group in the historiographical field of research has included biographical studies. Scientific biography has been a longstanding and important component of scholarly research. The heritage of V.A. Shenderovsky "May the Light of Science not Go Out", where the scientist presents essays on the activities of Ukrainian scientists (Shenderovsky, 2003) was useful for the historiographical investigation. The special attention is attracted by the great material devoted to the activity of the outstanding Ukrainian scientist I. Pulyui, who worked at the Prague Polytechnic and whose works were devoted to the analysis of three-phase and single-phase alternators of alternating current and calculation of linear circuits and had a significant influence on the formation of some branches of theoretical fundamentals of electrical engineering.

In the publication of V.S. Savchuk, A.V. Siukh "Heorhii Yevhenovych Yevreinov – a significant character of mining science" the scientific biography of the famous scientist in the field of mining electrical engineering was reproduced. Under his leadership a new scientific direction – research in the field of mining electrical engineering was formed, and engineers were trained according to a new specialization. H.Y. Yevreinov was the author of works which covered theoretical questions of electric drives of mining machines and mechanisms, and underground electromechanical equipment; he was at the origins of the creation in 1921 the Department of Mining Electrical Engineering. His fruitful scientific and pedagogical activity led to the creation of the school of young electrical engineers at the Dnipropetrovsk Mining Institute (DMI) (Savchuk, Siukh, 2012).

A number of works by A.E. Tverytnykova are devoted to the biographical analysis of the activities of prominent Kharkiv scientists in the field of electrical engineering. In 1892, the famous pioneer scientist O.K. Pogorelko, who was familiar with the organisation of electrical engineering research centres in Europe, started teaching electrical engineering at KhTI and insisted on compulsory inclusion of the elementary course of electrical engineering with the curriculum of the institute (Tverytnykova, 2006: 99–104). P.P. Kopnyaev started actions on organisation of teaching disciplines of electrotechnical profile at KhTI, promoted expansion of material and technical base of the departments for further growth and systematisation of scientific research, started publishing textbooks and manuals, in which he methodically summarised the material from all electrotechnical directions (Tverytnykova, 2005: 159–162).

In the publication of A.Yu. Koltachikhina "New Pages from the Life of a Theoretical Physicist Leon Yosypovych Kordysh" the author considers unknown pages from the life of the theoretical physicist. Working as a head of the Department of Electrical Engineering in the 1930s at the KPI, the scientist was the first to propose a syllabus for a lecture course on TFE, and he also worked out a laboratory practice for the students of the Faculty of Electrical Engineering (Koltachikhina, 2006).

A significant role of a scientific leader in the development of a particular scientific field is revealed by the biographical publication of S.A. Khorosheva "Scientific school of G.E. Pukhov in the field of mathematical modelling" (Khorosheva, 2007). On the example of the description of the way of life of the outstanding scientist in the field of theoretical electrical engineering G.E. Pukhov revealed the development of one of the most successful technical scientific schools in Ukraine – the school of mathematical modelling in energy field. Under the leadership of the scientist, the innovative research was conducted in the field of modelling theory, computer science and control theory, the theory of quasi-analog modelling was developed.

Conclusions. Therefore, the detailed historiographical analysis of the available literature has shown that at this time there is no comprehensive and substantiated study of the formation and development of the scientific field on the theoretical foundations of electrical engineering in Ukraine. The author has found that the works of the first historiographical period, although they contain a sufficient amount of factual material on the development of the theory of electricity, but have virtually no mention of Ukrainian scientists and the formation of domestic theoretical electrical engineering. The historiography of the period of independent Ukraine is characterized by an increase in various scientific studies on the history of theoretical electrical engineering and training of scientific and engineering personnel. There are also works in which the development of theoretical electrical engineering is revealed through the prism of the activities of the prominent Ukrainian scientists and scientific schools. But the published works only fragmentarily reveal the stages of the development of theoretical electrical engineering in certain technical educational institutions and research institutions. In addition, the general scientific analysis has not been made in Ukraine and some issues remain unexplored, which in turn determined the direction of further scientific research of the author.

Bibliography:

1. Белькинд Л.Д. Чарлз Протеус Штейнмец (1867–1923). Научно-биографическая серия. Москва, 1965. 124 с.
2. Белькинд Л.Д., Каменева В.А. Из истории электротехники. Павел Петрович Копняев. *Электричество*. 1967. № 9. С. 83.
3. Бессонов Л.А. О необходимых мероприятиях для улучшения подготовки студентов по теоретическим основам электротехники. *Электричество*. 1963, № 8. С. 83–85.
4. Борисенко А.Н., Резинкин О.Л., Самсонов В.П., Тверитникова Е.Е. Кафедра теоретических основ электротехники. 80 лет в ХПИ. *Вісник НТУ «ХПІ»*. Харків, 2011. № 57. С. 3–8.
5. Брон О.Б. Вопросы преподавания курса «Теоретические основы электротехники». *Электричество*. 1964. № 9. С. 88–89.
6. Веников В.А., Князевский Б.А., Соколов В.И. Вклад Советской высшей электроэнергетической школы в научные исследования по электротехнике и электроэнергетике за 50 лет. *Энергетика*. 1967. № 11. С.1–15.
7. Воробкевич А.Ю., Рокіцький О.М, Шендеровський В.А. Початок фізичних і електротехнічних досліджень у Львівський політехніці. *Актуальні питання історії техніки* : матеріали 2-ї Всеукр. наук. конф. Київ : ЕКМО, 2003. С. 17–21.
8. Демирчан К.С., Нетушил А.В. Развитие теоретических основ электротехники за 60 лет Советской власти. *Электричество*. 1977. № 12. С. 3–11.
9. История электротехники / под ред. И.А. Глебова. Москва : изд. МЭИ, 1999. 524 с.
10. История энергетической техники СССР. Т. 2. Электротехника: в 3-х т. / ред. Л.Д. Белькинд. Москва; Ленинград : ГОСЭНЕРГОИЗДАТ, 1957. 728 с.
11. Київський політехнічний інститут. Нарис історії. / ред. Г.Ф. Бєляков, Є.С. Василенко, М.Ф. Вілков та ін. Київ : Наукова думка, 1995. 320 с.
12. Кляцкин И.Г. Из истории электротехники. Генрих Герц к 100-летию со дня рождения. *Электричество*. 1957. № 3. С. 70–73.
13. Колтачихіна О.Ю. Нові сторінки з життя фізика-теоретика Леона Йосиповича Кордиша. *Наука та наукознавство*. 2006, № 4. С. 61–70.
14. Кузнецов Б.Г. История энергетической техники. Москва–Ленинград : ОНТИ, 1937. 312 с.
15. Лебедев В.И. Электричество, магнетизм, электротехника в её историческом развитии. Москва–Ленинград : ОНТИ, 1937. 176 с.
16. Милях А.Н., Чиженко И.М., Шидловский А.К. Развитие электротехнической науки на Украине. *Техническая электродинамика*. 1980 № 6. С. 13–24.
17. Милях А.М., Кирпатовский С.И. Из истории становления и развития теоретических основ электротехники на Украине. *Теоретическая электротехника :* сб. научн. тр. Львов : Издательство Львовского университета, Вып. № 3. 1967. С. 3–15.
18. Миткевич В.Ф. Работы Фарадея и современное развитие приложений электрической энергии. Москва–Ленинград : ГТТИ, 1932. 20 с.
19. Радовский М.И. Из истории электротехники. К 150-летию со дня рождения Ома. *Электричество*. 1939. № 12. С. 59–61.
20. Розов В.Ю. К 40-летию научно-технического центра магнетизма технических объектов НАН Украины. История, достижения, перспективы. *Технічна електродинаміка*. 2010. № 3. С. 74–80.
21. Савчук В.С., Сюх А.В. Георгій Євгенович Євреїнов – знакова постать гірничої науки. *Наддніпрянська Україна: історичні процеси, події, постаті*. Дніпропетровськ : Видавництво ДНУ. 2012. Вип 10. С. 193–204.
22. Симоненко О.Д. Электротехническая наука в первой половине XX века : монография. Москва : Наука, 1988. 144 с.
23. Слободян Л.Р., Трофимова Н.В. До історії кафедри теоретичних основ електротехніки КПІ. *Питання історії науки і техніки*. Київ, 2011 № 2. С. 43–47.
24. Слободян Н.Р., Трофимова Н.В., Чибеліс В.І. Становлення та розвиток теоретичної електротехніки у вищих навчальних закладах України. *Питання історії науки і техніки*. 2014. № 1. С. 2–11.
25. Спінул Л.Ю., Галушко В.В., Гришко О.С. До 100-річчя факультету електроенергетики та автоматики: Артем'єв М.А. – засновник електротехнічної школи у Київській політехніці. *Міжнародний науково-технічний журнал «Сучасні проблеми електроенергетики та автоматики»*, Київ, 2018. С. 630–634.
26. Страхов С.В. Современное состояние и перспективы развития курса «Теоретические основы электротехники». *Электричество*. 1964. № 4. С. 86–87.
27. Тверитникова О.Є. Зародження і розвиток науково-технічної школи електротехніки професора П.П. Копняєва (1885–1950 рр.). Харків : Вісник НТУ «ХПІ», 2010. 212 с.
28. Тверитникова О.Є. Науковий доробок і громадська діяльність професора О.К. Погорєлка. *Наука та наукознавство*. Київ : вид-во ППВФ «Фенікс», 2006. № 2. С. 99–104.
29. Тверитникова О.Є. Науково-педагогічна діяльність П.П. Копняєва. (Історичний екскурс). *Вісник НТУ «ХПІ»*. Харків : НТУ «ХПІ», 2005. № 7. С. 159–162
30. Тверитникова О.Є. Електротехнічна галузь України другої половини XX ст.: напрями розвитку і здобутки : монографія. Харків : ТОВ «Тім Пабліш Груп». 500 с.
31. Хвольсон О.Д. Физика наших дней. Новые понятия современной физики в общедоступном изложении. Москва–Ленинград : ГТТИ, 1932. 353 с.
32. Хорошева С.А. Наукова школа Г.Є Пухова в галузі математичного моделювання. *Наука та наукознавство.* 2007. № 4. Додаток. С. 189–202.

33. Храмов Ю.А. История формирования и развития физических школ на Украине. Киев : МП «Феникс», 1991. 216 с.
34. Храмов Ю.О. Фізика. Історія фундаментальних ідей, теорій та відкриттів : монографія. Київ : МП «Феникс», 2012. 816 с.
35. Храмов Ю.А. Новый подход к построению истории фундаментальной науки. *Наука та наукознавство.* 2017. № 2 (95). С. 112–125.
36. Хренов К.К. Вклад украинских ученых в развитие советской науки и техники. *Известия АН СССР*. 1954. № 1. С. 3–13.
37. Хрущов В.М. Харьковский электротехнический институт. *Электричество*. 1941. № 5. С. 25–31.
38. Цымбал Е.И., Никулин В.В. Одесский политехнический институт: краткий исторический очерк. Киев : Издательство Киевского университета, 1968. 223 с.
39. Шендеровський В.А. Нехай не гасне світ науки / за редакцією Е. Бабчук. Київ : Рада, 2003. 416 с.
40. Шидловська Н.А. Дослідження з теоретичної електротехніки у відділах Інституту електродинаміки НАН України. *Технічна електродинаміка.* 2007. № 4. С. 20–25.
41. Шидловський А.К. Гортаючи сторінки історії. *Технічна електродинаміка*. 2007. № 3. С. 3–10.
42. Шидловский А.К. Інститут електродинаміки НАН України. Історія, здобутки, перспективи. *Технічна електродинаміка*. 1997. № 1. С. 3–11.
43. Шостьин Н.А. Из истории науки. Джеймс Клерк Максвелл. *Электричество*. 1940. № 5. С. 54–59.

References:

1. Belkind, L.D. (1965). Charlz Proteus Shteinmetc (1867–1923) [Charles Proteus Steinmetz (1867–1923)]. Nauchno-biograficheskaia seriia. Moskva. 124 p. [in Russian].
2. Belkind, L.D., Kameneva, V.A. (1967). Iz istorii elektrotekhniki. Pavel Petrovich Kopniaev [From the history of electrical engineering. Pavel Petrovich Kopnyaev]. *Elektrichestvo*. No. 9. p. 83 [in Russian].
3. Bessonov, L.A. (1963). O neobkhodimykh meropriiatiiakh dlia uluchsheniia podgotovki studentov po teoreticheskim osnovam elektrotekhniki [On the necessary measures to improve the training of students in the theoretical foundations of electrical engineering]. *Elektrichestvo.* No. 8. Pp. 83–85 [in Russian].
4. Borisenko, A.N., Rezinkin, O.L., Samsonov, V. P., Tveritnikova, E.E. (2011). Kafedra teoreticheskikh osnov elektrotekhniki. 80 let v KhPI [Department of Theoretical Foundations of Electrical Engineering. 80 years in KhPI]. *Visnik NTU "KhPI".* Kharkiv. No. 57. Pp. 3–8 [in Russian].
5. Bron, O.B. (1964). Voprosy prepodavaniia kursa "Teoreticheskie osnovy elektrotekhniki" [Questions of teaching the course "Theoretical Foundations of Electrical Engineering"]. *Elektrichestvo*. No. 9. Pp. 88–89 [in Russian].
6. Venikov, V.A., Kniazevskii, B.A., Sokolov, V.I. (1967). Vklad Sovetskoi vysshei elektroenergeticheskoi shkoly v nauchnye issledovaniia po elektrotekhnike i elektroenergetike za 50 let [The contribution of the Soviet Higher Electric Power School to scientific research in electrical engineering and power engineering for 50 years]. *Energetika*. No. 11. Pp. 1–15 [in Russian].
7. Vorobkevych, A.Yu., Rokitskyi, O.M. Shenderovskyi, V.A. (2003). Pochatok fizychnykh i elektrotekhnichnykh doslidzhen u Lvivskyi politekhnitsi. [Earb of physical and electrical technical education at Lviv Polytechnic]. *Aktualni pytannia istorii tekhniky: materialy 2-yi Vseukr. nauk. konf*. Kyiv: EKMO, 2003. Pp. 17–21 [in Ukrainian].
8. Demirchan, K.S., Netushil, A.V. (1977). Razvitie teoreticheskikh osnov elektrotekhniki za 60 let Sovetskoi vlasti [Development of the theoretical foundations of electrical engineering during 60 years of Soviet power]. *Elektrichestvo.* No. 12. Pp. 3–11 [in Russian].
9. Istoriia elektrotekhniki [History of electrical engineering] / pod red. I.A. Glebova (1999). Moskva: izd. MEI. 524 p. [in Russian].
10. Istoriia energeticheskoi tekhniki SSSR [History of power engineering of the USSR] T. 2. Elektrotekhnika: v 3-kh t. / red. L.D. Belkind (1957). Moskva. Leningrad: GOSENERGOIZDAT. 728 p. [in Russian].
11. Kyivskyi politekhnichnyi instytut. Narys istorii [Kyiv Polytechnic Institute. Essay on history] / red. H.F. Bieliakov, Ye.S. Vasylenko, M.F. Vilkov ta in. (1995). Kyiv: Naukova dumka. 320 p. [in Ukrainian].
12. Kliatckin, I.G. (1957). Iz istorii elektrotekhniki. Genrikh Gertc k 100-letiiu so dnia rozhdeniia [From the history of electrical engineering. Heinrich Hertz on the 100th anniversary of his birth]. *Elektrichestvo*. No. 3. Pp. 70–73 [in Russian].
13. Koltachykhina, O.Yu. (2006). Novi storinky z zhyttia fizyka-teoretyka Leona Yosypovycha Kordysha [New pages from the life of the theoretical physicist Leon Kordysh]. *Nauka ta naukoznavstvo*. 2006, No. 4. Pp. 61–70 [in Ukrainian].
14. Kuznetcov, B.G. (1937). Istoriia energeticheskoi tekhniki [History of power engineering]. Moskva–Leningrad: ONTI. 312 p. [in Russian].
15. Lebedev, V.I. (1937). Elektrichestvo, magnetizm, elektrotekhnika v yeye istoricheskom razvitii [Electricity, magnetism, electrical engineering in its historical development]. Moskva–Leningrad: ONTI. 176 p. [in Russian].
16. Miliakh, A.N., Chizhenko, I.M., Shidlovskii, A.K. (1980). Razvitie elektrotekhnicheskoi nauki na Ukraine [Development of electrical engineering science in Ukraine]. *Tekhnicheskaia elektrodinamika*. No. 6. Pp. 13–24 [in Russian].
17. Miliakh, A.M., Kirpatovskii, S.I. (1967). Iz istorii stanovleniia i razvitiia teoreticheskikh osnov elektrotekhniki na Ukraine [From the history of the formation and development of the theoretical foundations of electrical engineering in Ukraine]. *Teoreticheskaia elektrotekhnika*: sb. nauchn. tr. Lvov: Izdatelstvo Lvovskogo Universiteta, Issue 3. 1967. pp. 3–15 [in Russian].
18. Mitkevich, V.F. (1932). Raboty Faradeia i sovremennoe razvitie prilozhenii elektricheskoi energii [Faraday's work and modern development of electrical energy applications]. Moskva–Leningrad: GTTI. 20 p. [in Russian].
19. Radovskii, M.I. (1939). Iz istorii elektrotekhniki. K 150-letiiu so dnia rozhdeniia Oma [From the history of electrical engineering. On the 150th anniversary of the birth of Ohm]. *Elektrichestvo*. No. 12. Pp. 59–61 [in Russian].

20. Rozov, V.Iu. (2010). K 40-letiiu nauchno-tekhnicheskogo tcentra magnetizma tekhnicheskikh obektov NAN Ukrainy. Istoriia, dostizheniia, perspektivy [To the 40th anniversary of the scientific and technical center of magnetism of technical objects of the National Academy of Sciences of Ukraine. History, achievements, prospects]. *Tekhnichna elektrodinamika*. No. 3. Pp. 74–80 [in Russian].
21. Savchuk, V.S., Siukh, A.V. (2012). Heorhii Yevhenovych Yevreinov – znakova postat hirnychoi nauky [Georgy Yevgenyevich Evreinov is an iconic figure of mining science]. *Naddniprianska Ukraina: istorychni protsesy, podii, postati*. Dnipropetrovsk: Vydavnytstvo DNU. Issue 10. Pp. 193–204 [in Ukrainian].
22. Simonenko, O.D. (1988). Elektrotekhnicheskaia nauka v pervoi polovine XX veka: monografiia [Electrical Science in the First Half of the 20th Century: Monograph]. Moskva: Nauka. 144 p. [in Russian].
23. Slobodian, L.R., Trofymova, N.V. (2011). Do istorii kafedry teoretychnykh osnov elektrotekhniky KPI [To the history of the department of theoretical bases of electrical engineering of KPI]. *Pytannia istorii nauky i tekhniky*. Kyiv. No. 2. Pp. 43–47 [in Ukrainian].
24. Slobodian, N.R., Trofymova, N.V., Chybelis, V.I. (2014). Stanovlennia ta rozvytok teoretychnoi elektrotekhniky v vyshchykh navchalnykh zakladakh Ukrainy [Formation and development of theoretical electrical engineering in higher educational institutions of Ukraine]. *Pytannia istorii nauky i tekhniky*. 2014. No. 1. Pp. 2–11 [in Ukrainian].
25. Spinul, L.Yu., Halushko, V.V., Hryshko, O.S. (2018). Do 100-richchia fakultetu elektroenerhetyky ta avtomatyky: Artemiev M.A. – zasnovnyk elektrotekhnichnoi shkoly u Kyivskii politekhnitsi [To the 100th anniversary of the Faculty of Power Engineering and Automation: Artemyev M.A. – founder of the Electrical Engineering School at Kyiv Polytechnic]. *Mizhnarodnyi naukovo-tekhnichnyi zhurnal "Suchasni problemy elektroenerhetyky ta avtomatyky"*. Kyiv, 2018. Pp. 630–634 [in Ukrainian].
26. Strakhov, S.V. (1964). Sovremennoe sostoianie i perspektivy razvitiia kursa "Teoreticheskie osnovy elektrotekhniki" [Current state and development prospects of the course "Theoretical Foundations of Electrical Engineering"]. *Elektrichestvo*. No. 4. Pp. 86–87 [in Russian].
27. Tverytnykova, O.Ye. (2010). Zarodzhennia i rozvytok naukovo-tekhnichnoi shkoly elektrotekhniky profesora P.P. Kopniaieva (1885–1950 rr.). [Origin and development of the scientific and technical school of electrical engineering of Professor P.P. Kopnyaeva (1885–1950)]. Kharkiv: NTU "KhPI". 212 p. [in Ukrainian].
28. Tverytnykova, O.Ye. (2006). Naukovyi dorobok i hromadska diialnist profesora O.K. Pohorielka [Scientific achievements and public activity of Professor O.K. Pogorelko]. *Nauka ta naukoznavstvo*. Kyiv: vyd-vo PPVF "Feniks". No. 2. Pp. 99–104 [in Ukrainian].
29. Tverytnykova, O.Ye. (2005). Naukovo-pedahohichna diialnist P.P. Kopniaieva (Istorychnyi ekskurs). [Scientific and pedagogical activity of P.P. Kopnyaev. Historical excursion]. *Visnyk NTU "KhPI"*. Kharkiv: NTU "KhPI". No. 7. Pp.159–162 [in Ukrainian].
30. Tverytnykova, O.Ye. (2017). Elektrotekhnichna haluz Ukrainy druhoi polovyny XX st.: napriamy rozvytku i zdobutky: monohrafiia [Electrotechnical branch of Ukraine of the second half of the XX century: directions of development and achievements]. Kharkiv: TOV "Tim Pablish Hrup". 500 p. [in Ukrainian].
31. Khvolson, O.D. (1932). Fizika nashikh dnei. Novye poniatiia sovremennoi fiziki v obshchedostupnom izlozhenii [Physics of our days. New concepts of modern physics in a public presentation]. Moskva–Leningrad: GTTI. 353 p. [in Russian].
32. Khorosheva, S.A. (2007). Naukova shkola H.Ie. Pukhova v haluzi matematychnoho modeliuvannia [G.E. Pukhov Scientific School in the field of mathematical modeling]. *Nauka ta naukoznavstvo*. No. 4. Dodatok. Pp.189–202 [in Ukrainian].
33. Khramov, Iu.A. (1991). Istoriia formirovaniia i razvitiia fizicheskikh shkol na Ukraine [The history of the formation and development of physical schools in Ukraine]. Kyiv: MP "Feniks". 216 p. [in Russian].
34. Khramov, Yu.O. (2012). Fizyka. Istoriia fundamentalnykh idei, teorii ta vidkryttiv: monohrafiia [Physics. History of fundamental ideas, theories and discoveries]. Kyiv: MP "Feniks". 816 p. [in Ukrainian].
35. Khramov, Iu.A. (2017). Novyi podkhod k postroeniiu istorii fundamentalnoi nauki [A new approach to building the history of fundamental science]. *Nauka ta naukoznavstv*o. No. 2 (95). Pp. 112–125 [in Russian].
36. Khrenov, K.K. (1954). Vklad ukrainskikh uchenykh v razvitie sovetskoi nauki i tekhniki [The contribution of Ukrainian scientists to the development of Soviet science and technology]. *Izvestiia AN SSSR*. No. 1. Pp. 3–13 [in Russian].
37. Khrushchov, V.M. (1941) Kharkovskii elektrotekhnicheskii institute [Kharkov Electrotechnical Institute]. *Elektrichestvo*. 1941. No 5. Pp. 25–31.
38. Tcymbal, E.I., Nikulin, V.V. (1968). Odesskii politekhnicheskii institut: kratkii istoricheskii ocherk [Odessa Polytechnic Institute: A Brief Historical Sketch]. Kiev: Izdatelstvo Kievskogo universiteta. 223 p. [in Russian].
39. Shenderovskyi, V.A. (2003). Nekhai ne hasne svit nauky [Let the world of science not go out] / za redaktsiieiu E. Babchuk. Kyiv: Rada. 416 p. [in Ukrainian].
40. Shydlovska, N.A. (2007). Doslidzhennia z teoretychnoi elektrotekhniky u viddilakh Instytutu elektrodynamiky NAN Ukrainy [Research in theoretical electrical engineering in the departments of the Institute of Electrodynamics of the National Academy of Sciences of Ukraine]. *Tekhnichna elektrodynamika*. No. 4. Pp. 20–25 [in Ukrainian].
41. Shydlovskyi, A.K. (2007). Hortaiuchy storinky istorii [Flipping through the pages of history]. *Tekhnichna elektrodynamika*. No. 3. Pp. 3–10 [in Ukrainian].
42. Shydlovskyi, A.K. (1997). Instytut elektrodynamiky NAN Ukrainy. Istoriia zdobutky, perspektyvy [Institute of Electrodynamics of the National Academy of Sciences of Ukraine. History of achievements, prospects]. *Tekhnichna elektrodynamika*. No. 1. Pp. 3–11 [in Ukrainian].
43. Shostin, N.A. (1940). Iz istorii nauki. Dzhems Klerk Maksvell [From the history of science. James Clerk Maxwell]. *Elektrichestvo*. No. 5. Pp. 54–59 [in Russian].