REVIEW ARTICLE
DOI: https://doi.org/10.30932/1992-3252-2022-6-11

World of Transport and Transportation, 2022,
Vol. 20, Iss. 6 (103), pp. 212–220

Ivan Gavrilovich Alexandrov. Pages of Life and Achievements

Nikolay D. GRIGORIEV

Nikolay D. Grigoriev
Ph.D. (Eng), Moscow, Russia.
✉ *9165688074@yandex.ru.*

ABSTRACT

Academician Ivan Gavrilovich Alexandrov is an outstanding hydropower engineer, the founder of the integrated design of large hydroelectric plants and irrigation systems, the developer of the GOELRO plan, the author of original innovative ideas, which then seriously influenced further development of hydropower engineering and are still of practical importance, the creator of DneproGES. The Angarsk HPP cascade was also designed according to the developments and proposals of Ivan G. Alexandrov. A brilliant researcher, designer, economist, teacher, manager, and administrator graduated from Moscow Engineering School (now Russian University of Transport).

Ivan Alexandrov was recognised worldwide as an outstanding scientist and engineer. His activities mainly fell on the most difficult years of formation of the national economy of the USSR, on the years of the first five-year plans…

For many years he taught at the higher educational institutions of Leningrad and Moscow and enjoyed great love and respect among students.

Keywords: history of engineering, GOELRO plan, hydropower engineering, railway, bridge building, economic zoning.

For citation: Grigoriev, N. D. Ivan Gavrilovich Alexandrov. Pages of Life and Achievements. World of Transport and Transportation, 2022, Vol. 20, Iss. 6 (103), pp. 212–220. DOI: https://doi.org/10.30932/1992-3252-2022-6-11.

The text of the article originally written in Russian is published in the first part of the issue.
Текст статьи на русском языке публикуется в первой части данного выпуска.

FIRST STEPS...

I. G. Alexandrov was born in Moscow on August 20, 1875. Margarita Vasilievna (née Belyaeva), the mother of the future scientist, sang in the choir of the Bolshoi Theatre. During the Turkish campaign she followed her husband, military paramedic Gavril Ivanovich Aleksandrov, voluntarily to the front as a sister of mercy. After the end of the Russian-Turkish war, Margarita Vasilievna never returned to the theatre, but continued to serve as a nurse at the Sheremetyevo hospital, where her husband worked as a paramedic and apprentice pharmacist.

When their son was ten years old, he was assigned to the Moscow real school. The Alexandrov family was not wealthy, so the young realist had to give lessons, making «his personal contribution» to the family's common piggy bank.

Of all the subjects that were included in the curriculum, Vanya was most interested in mathematics and geography.

«Only two subjects», he later wrote (1903), «attracted me: this was mathematics and geography, especially geography, and there were special signs for this. *This science was taught by Yanchin – a very high personality in his inner content. His lessons were a living acquaintance with the world; plants, stones, pictures, devices, maps were brought. And his speech, simple and strong love for the cause, fascinated me. He did not know this until his death, but I loved him directly, and to this day Yanchin's personality has not been erased from a number of the best people that I have ever met in my life.*

If we add to this his deep understanding of children and his attitude towards them that is just to the point of scrupulousness, then I think… this bright personality of the teacher will become clear. He died (from pneumonia) when I was already in the sixth grade, and I sobbed like a child at a memorial service for him, as if I were losing the closest and dearest thing that connected me with the school» [1, p. 10].

In his letters dated 1903, Ivan Gavrilovich reported many interesting facts about the situation in real schools in the 80s of 19th century.

«*In order to find out the atmosphere of the school, I will focus on a few more people… I'll start with the director. His name was Alexander Alexandrovich Krivonosov. Imagine a stout, stocky old man, but not fat, with lively stubborn black eyes, always serious, with an «o» accent. The first impression was far from being in his favour – terrible formalism was immediately evident, wherever he was, whether he took firewood for the school, whether he examined the students' ties, or told some arithmetical wisdom to the first-grade students. Penalties were always imposed on us, even for trifles: for a torn off belt from a satchel, for lack of buttons, and so on. But over time, other sides began to emerge. It turned out that the director gets up at 5 o'clock in the morning, inspects all the sheds, classrooms, halls, checks the air temperature everywhere, operation of ventilation; he comes to the lesson without being even a minute late, and does not keep the students longer than the appointed time… I remember one case that is especially noteworthy: Krivonosov's son shot himself just at the time when he was reading arithmetic in the first class; to tell him about it, one teacher ran into the class; hearing the news, the director turned terribly pale, somehow haggard at once and said: «I will finish the lesson and come back». From this phrase, I found tetanus right on everyone, and he finished the lesson and quickly left. The son is dead…»* [1, p. 11].

Getting an education in a real school was the ultimate dream for many. In the lower grades of the school, Alexandrov showed a penchant for drawing and manual labour. Over the years this has become a real skill. Being already a family man, Ivan Gavrilovich made scenery for home performances, he liked to draw with a pencil or watercolour. For many years, Ivan Gavrilovich was engaged in amateur photography, and, according to eyewitnesses, he did it perfectly.

And once, while working in 1906 in the city of Shatsk, in his free time, Alexandrov professionally cleared a large, neglected garden without outside help, giving it a new life. A few years later, already at the rank of professor in St. Petersburg, Ivan Gavrilovich built models of two famous St. Petersburg bridges, one of which was drawbridge. The models were made from different types of wood and reproduced the bridges with amazing accuracy.

According to Ivan Gavrilovich himself, these «minor hobbies» played an important role in his life, during childhood, they contributed to development of labour skills and ingenuity, later turned into a perfect rest time.

In 1894, Ivan Gavrilovich completed his studies at a real school and entered Moscow Technical School (now Bauman Moscow State Technical University). This educational

institution was then the best in Russia and probably in the world…

Moscow Technical School trained highly educated engineers with a broad scientific and technical outlook. In those years, the great Nikolai Egorovich Zhukovsky, the author of remarkable works on theoretical mechanics, hydraulics and aerodynamics, lectured there; he rightly believed that there was no and could not be a «pure», abstract science divorced from practice [1, p. 15]. Zhukovsky became for the future academician the ideal of an engineer of the highest type with a huge scientific and technical professional range.

Evgeny Paton, who was still a very young professor at that time, also lectured at the school. Over time, Alexandrov and Paton became friends, and they built more than one bridge together. During his third year at the school, Ivan Gavrilovich became interested in bridge building. The well-known St. Petersburg journal «Zodchiy», which Alexandrov regularly read, published descriptions of the most interesting bridge projects and articles on bridge building, illustrated with drawings, photographs and pictures. The largest Russian bridge engineer G. G. Krivoshein published an article in the journal calling for raising domestic bridge building to the level of genuine art, combining complex engineering structures and structures with architecture [2, p. 1]. It was these ideas that were embodied in the project of Borodino bridge in Moscow, presented by a group of engineers comprising G. G. Krivoshein, I. G. Alexandrov and architects V. A. Pokrovsky, E. I. Konstantinovich for a competition announced in connection with the centenary of Borodinsky battle. The project, which participated in the competition under the motto «Moscow–Muscovites», according to the architect P. V. Shchusev «…emphasi*sed the national character of the monument, reviving the traditions of the glorious builders of the Great Stone Bridge in the forms of Russian stone architecture»* [3].

Therefore, in 1898, student Alexandrov decided to transfer to the newly formed Moscow Engineering School (much later Russian University of Transport), which in those years did not even have its own building and was temporarily located on Tverskaya street, in a rented house.

The school was headed by one of its founders, a well-known Russian track engineer Professor F. E. Maksimenko. The course of study was designed for five years: three years of theoretical studies and two years of practice on the railway. After successfully completing the internship, the student was allowed to defend the graduation project.

At Moscow Engineering School Alexandrov studied under the guidance of outstanding scientists and engineers of that time. The course of higher mathematics was read by Professor B. K. Mlodzievsky, courses in chemistry and building materials by Professor I. A. Kablukov. Physics and electrical engineering were taught by engineer A. A. Eikhenvald, theoretical mechanics by Professor S. A. Chaplygin. The road course was taught by the famous builder, military engineer I. I. Rerberg. Professor F. E. Maksimenko taught hydraulics.

All teachers of special engineering disciplines were major practical engineers. This combination of pedagogical and engineering practices was an excellent example for students. Future engineers were offered a view of pedagogical work as the duty of a specialist. This view of teaching was also preserved by Alexandrov. In 1901, Ivan Gavrilovich graduated from the theoretical course of the Engineering School. He completed his internship at the construction of Orenburg–Tashkent railway, where he designed track structures: bridges, viaducts, water supply. Then he moved to the position of «head of the construction distance» and supervised the construction of the structures he designed.

During his practice, Ivan Alexandrov naturally encountered issues of irrigation and water supply, the importance of which for Central Asia can hardly be overestimated. Apparently, it was then that he became seriously interested in «water problems». It was then that Alexandrov's path to the world of large-scale hydropower and hydraulic engineering began.

In 1903, after completing his internship, Ivan Gavrilovich returned to Moscow, presented a detailed report on the work performed, defended his diploma and was approved as a civil engineer and again left for Central Asia to build a new section of Orenburg–Tashkent railway at Turkestan station [4–6].

Moscow, Paton, Bridges…

A year later, Ivan Gavrilovich returned to Moscow again and, under the guidance of Evgeny Paton, began to design large bridges. In tandem with Paton, some issues of construction technology were developed, in particular, the calculation of additional stresses depending on rigidity of the riveted nodes of bridge trusses.

In 1906 because of the famine in Tambov province, mass public works were organised, where Alexandrov received his new appointment. Ivan Gavrilovich was supposed to supervise all these works in the district town of Shatsk. During the year in this position, he designed and built several bridges and dams, as well as more than 100 small engineering structures.

From Shatsk, Alexandrov moved to St. Petersburg and entered the technical office of G. B. Krasin as a senior engineer; there he designed rafters and bridges for Simbirsk–Ufa railroad, reinforced concrete pipes for Middle Amur Railway and lock gates for the Western Dvina River.

In 1909, Alexandrov was invited by St. Petersburg Metal Works to design the Finland Bridge across the Neva. At the end of the project, he supervised the construction of this bridge. At the same time, Ivan Gavrilovich, together with Professor G. G. Krivoshein created projects of bridges: across the Volga near the town of Staritsa with a span of 75 sazhens (160 meters) and a competitive project for the Borodino bridge in Moscow [1, pp. 17–19].

Irrigation in Central Asia

In 1912, Ivan Gavrilovich was invited to work at the Department of Land Improvements of the Ministry of Agriculture. He readily accepted this proposal, since he had long ago decided to devote himself to the problems of hydraulic engineering and mainly to the use of «white coal», i.e., hydropower.

However, during the year Alexandrov was not engaged in hydraulic engineering and hydropower engineering but designed reinforced concrete bridges across irrigation canals in the Hungry Steppe of Turkestan. Around the same time, he completed a draft design of a typical hydroelectric station, intended for construction on the drops of irrigation canals.

The following year, Ivan Gavrilovich was appointed head of survey work in the Syr Darya basin, where reservoirs were to be built in the upper reaches of the river for the purpose of irrigation.

The appointment of a young talented engineer seemed strange to many. It was not clear why the Ministry of Agriculture needed to send a gifted Petersburg engineer to the very backwoods of the empire, to the distant Syr Darya River.

Before the First World War, the interest of the government and private capital in the problems of irrigating the fertile lands of Central Asia sharply increased. Irrigation of Turkestan became the most important condition for strengthening

exploration of this territory. Only by irrigating the local lands could Russian settlers be resettled there to become the support and defenders of the interests of the autocracy in Turkestan.

Working in the Syr Darya basin, Ivan Gavrilovich first appeared as a researcher and irrigator. This became a «prelude» to his famous projects of the largest hydroelectric power plants (including those in Central Asia). Ivan Gavrilovich already then predicted the great importance of the Central Asian rivers as a powerful source for obtaining cheap electrical energy. The ideas put forward by Alexandrov about combining irrigation tasks with obtaining cheap electricity were completely original [1, pp. 20–25].

Exploration work in Central Asia was carried out in the summer months, after which in the fall he and his assistants returned to St. Petersburg, where they carried out office processing of the materials obtained during the expedition.

As a result, Ivan Gavrilovich proposed a completely other project, fundamentally different from the previous ones in that the waters of smaller mountain rivers flowing from the Altai Range were used for irrigation. Such a solution made it possible to «build a dam and form a giant reservoir of water» [5].

After the revolution, Alexandrov went far beyond the scope of irrigation tasks. He combines irrigation and hydropower into a single complex.

GOELRO Plan and Economic Zoning

In 1918, Ivan Gavrilovich moved to Moscow and entered the Main Committee of State Structures of the Supreme Council of National Economy (Komgosoor). Since 1922, he began to work simultaneously in the State Planning Commission.

On behalf of Lenin, two hundred major Russian scientists and engineers, including Alexandrov, under the leadership of Gleb Krzhizhanovsky, began developing the world's first state plan for electrification. They were supposed to offer a solution on how to *«fill the whole country with electric light»* in the shortest possible time. Some of the «old school» people on this commission thought it was fantastic in their hearts.

On April 3, 1920, at a meeting of the GOELRO Commission, Ivan Gavrilovich made an extensive report on the program for economic development of the South of Russia. In it, he first brought a plan for creation of the Dnieper hydroelectric plant [7].

According to the GOELRO plan, 31 power plants were to be built. Nine of them were hydroelectric ones and were built according to Aleksandrov's designs.

The plan was fulfilled in conformity with the main indicators in 1931. Academician A. V. Vinter pointed out that in 1950 the annual power balance of the Soviet Union exceeded the target of the GOELRO plan by 15 times [1, p. 34].

In connection with the work of the GOELRO Commission, I. G. Alexandrov took part in the economic zoning of the country.

Academician S. G. Strumilin wrote: «It is known that the current regional division of the USSR was based on the scheme of economic regions of the State Planning Commission, developed under the direct supervision of I. G. *Aleksandrov. Thus, he was fortunate enough to firmly capture his creative thought already in the most general contours of the map of the USSR, on the grandiose scale of one-sixth of the globe. He also has the high honour to revive this map in its new outlines with bright nodal points of new powerful energy centres of such a scale as Dneprostroy*» [1, p. 37].

Particularly interesting is Alexandrov's substantiation of «the theory of economic location of production cent*res, the creation of industrial plants and the resolution of issues of super-mainline railways in the USSR»*. New methods of economic zoning were repeatedly the subject of the scientist's articles. Alexandrov always emphasised the great importance of economic zoning in our country. «Regional development», he wrote back in 1921, «allows establishing the closest connection between natural resources, the skills of the population, the values accumulated by the previous culture and new technology and obtain the best production combination, thus, on the one hand, an expedient division of labo*ur between separate regions, and on the other hand, by organising the region into a large combined economic system, which obviously achieves the best economic result»* [4].

At one time, it was I. G. Aleksandrov who began to develop the issues of the geographical location of industry and the creation of energy-industrial complexes, which should have included irrigation and transport systems [7–12].

DneproGES

The most outstanding project of I. G. Aleksandrov was the famous DneproGES. The Dnieper rapids – the so-called «curse of

nature», were an insurmountable natural barrier to through navigation and even made it difficult to raft timber – the ancient trade route «from the Varangians to the Greeks». There were nine main rapids in total. The total fall of the Dnieper (in the rapids part), which had a length of 65 km, was 30,85 m. The most dangerous rapids «Nenasytetsky» was nicknamed «Robber» by the pilots. In addition, above it was also the most insidious rock on the entire Dnieper – «Thunderstorm».

People wanted to solve the Dnieper problem for a long time. Back in 19th century, many scientists were engaged in the study of these rapids; more than one scientific article was devoted to the Dnieper and its rapids.

About 20 pre-revolutionary projects dedicated to the problems of the Dnieper are known. Nine of them are dedicated to improving navigation by clearing rapids, canals and locks, and 11 projects that address both navigation and water energy issues. Some projects also included schemes for using the waters of the Dnieper for irrigation of the Dnieper lands. These earlier projects always put shipping first. In later works, both tasks (shipping and energy) were considered as equivalent. And in Alexandrov's project, energy came to the fore.

On April 3, 1920, at a meeting of the GOELRO commission, Ivan Alexandrov said the following: «The rapids are not the misfortune of the Dnieper, but the value is no less, perhaps, than the *Krivoy Rog ore»*. Many years later, the arguments of the opponents of the Alexandrov project boiled down to the fact that there would be no one to consume the energy of such a large power plant [9].

The general design of the Dnieper hydroelectric power plant was ready by the end of 1920. And already in January 1921, a special design and survey organisation Dneprostroy was created, which, of course, was headed by Alexandrov. The development of the DneproGES project lasted five years.

The DneproGES project had no equal in world practice in terms of courage and innovation. «The mining South of Russia», Alexandrov writes, «represents one of the happiest combinations of natural resources that can be found: along with excellent soils and a warm climate, there are huge reserves of coal, iron, manganese, rock salt, kaolin and building material in the form of limestone, granite, gneiss, etc.» [6, p. 541].

What tasks did Aleksandrov set for his project?

1. Get the maximum amount of the cheapest hydraulic power.

2. Get the most powerful and cheapest form of transport conditions along the Dnieper.

3. Connect the main centres of minerals with cheap and powerful rail transport (electric lines).

4. Give a solution that would allow considering other meliorative possibilities.

Based on many years of research and a thorough analysis of the collected data, Alexandrov determined the water energy of the Dnieper at 3,963,000 hp. According to the project, the capacity of the DneproGES was estimated at 650,000 hp. Thanks to the participation of academicians A. V. Vinter and B. E. Vedeneev in the project, the power of the station during the construction process was increased and reached more than 800,000 hp.

Enormous engineering and economic problems were solved. At the head of everything Alexandrov put energy, on a scale that would make it possible to obtain a huge amount of cheap electrical energy. It was with this that the construction of a number of energy-intensive industries and other industrial enterprises in the centre of the industrial region of the Dnieper region was associated. Without considering energy in isolation, Ivan Gavrilovich solved all the numerous elements of the problems of the Dnieper in their interconnection.

DneproGES was conceived as the main engine of a giant industrial complex, which should include powerful metallurgical plants. This brought forward traffic problems. There was no connection with the regions of raw materials and consumption of finished products. It is obvious that a «super» road was needed: Zaporozhye–Donbass–Volgograd. The Dnieper, the most important water artery, was included in the transport scheme. Accordingly, a significant increase in the Aleksandrovsky railway junction was required…

Opponents to the project of I. G. Alexandrov spoke of the project as «*magic nonsense», «an undertaking that no one needs*», «*an ambitious invention*», etc. One professor argued that «*there will be no construction here for at least another fifty years*». A memorandum was submitted to the chairman of the Supreme Council of National Economy F. E. Dzerzhinsky about the untimeliness and uselessness of the Dneprostroy. It was signed by several engineers of the metallurgical plants of the South. Ivan Gavrilovich replied to this «*note*» with an article in which he gave a reasoned rebuff and provided indisputable evidence of «*the expediency and urgent need to create the Dnieper hydroelectric power plant for Soviet industry and economy»*. On November 4, 1926, the party and the government made a positive decision on the construction of the DneproGES [1, p. 62, 63].

On May 1, 1932, the Dnepropetrovsk hydroelectric plant gave its first current. On October 10, the grand opening took place. By this time, many enterprises had already received cheap electric energy with might and main. And the load on the station grew every month, and the number of consumers increased. DneproGES saved 10 thousand tons of coal per day.

In 1932, Ivan Alexandrov was awarded the Order of Lenin and was elected full member of the USSR Academy of Sciences [13].

Management of the Transport Commission of the Academy of Sciences of the USSR (1934–1936)

The main work of I. G. Alexandrov after being elected Academician proceeded in the field of transport, but, solving the major complex problems of transport of the USSR as a whole,

he connected them with the problems of energy and, in particular, hydropower, developing and deepening his favourite works on creation in our country of an extensive network of hydroelectric stations. Alexandrov wrote: «As it has now become clear, our transport must have its own special identity and special productivity in the political and social conditions in which our country lives and that even the technical forms that are available to us differ from everything that can be applied in bourgeois economy» [1, p. 104].

Many scientific works of I. G. Alexandrov are devoted to transport, including «New Transport», «Electrification and Transport» (co-authored with G. O. Graftio). In the work on economic zoning and reconstruction of the national economy of the USSR, transport problems and their solution occupied one of the main places. The scientist wanted to create such a transport system that was supposed to unite the entire territory of the Soviet Union into a single economic object.

In the 1930s, the so-called «limit theories» were actively developing in the USSR, which hampered the development of transport in the country. The Transport Commission faced the most important task – «to strike a crushing blow at the «pre-frontiers» that artificially retard the growth and development of our transport, and at the same time provide the broadest support for the movement of innovators, the first sprouts of which arose on various roads already at the end of 1934. In the Donbass, the young locomotive driver Pyotr *Krivonos, contrary to established norms and guidelines, overcoming the passive resistance of some specialists, has already achieved outstanding production achievements»*. «Now our machinists», I. G. Alexandrov wrote about Pyotr Krivonos and his followers, «*are proving to engineers… that the sacramental upper limit of tractive effort can also be increased and the steam locomotives «E» and «FD»* [editor's note: famous brands of powerful Soviet steam locomotives] *are beginning to show both greater speed and greater tractive effort than the traction engineers thought»*.

The leadership of the Transport Commission is the last job position of I. G. Alexandrov. As always, Ivan Gavrilovich fought against inertia and routine, outdated traditions, while remaining a champion of everything new and progressive. He considered the development of transport problems an urgent, vital task of the state.

Alexandrov suggested using the hydro potential of the Angara and Yenisei [14] and the construction of the Baikal-Amur Railway (BAM) as the main transport road to connect the centre of the USSR with the Pacific Ocean. The construction of BAM began in 1932, in 1951 it was suspended, and in 1974 it was resumed. Since 1933, he headed the Department of the Use of Water Energy at the Moscow Higher Construction Institute of the People's Commissariat for Heavy Industry of the USSR (now Moscow State University of Civil Engineering). He worked as a professor at the department of water flow regulation at Moscow Agricultural Academy named after K. A. Timiryazev (now Russian Agrarian University – Moscow Agricultural Academy named after K. A. Timiryazev) and in 1935 he was elected a full member of the All-Union Academy of Agricultural Sciences named after

V. I. Lenin. For many years of work in the State Planning Committee of the USSR in 1936 he was awarded the Order of the Red Banner of Labour. He was the author of projects of bridges across the rivers Neva, Volga, Moskva, hydroelectric power plants, irrigation of land and construction of railways [6, pp. 510–512].

It is surprising that with such a workload, Ivan Gavrilovich still had time and energy for pedagogical work, which he had been doing for more than two decades.

On May 2, 1936, at about 9 o'clock in the morning, Ivan Gavrilovich died. On May 4, all the central newspapers printed extensive obituaries and numerous announcements from various organisations about the death of Academician I. G. Alexandrov. The obituary, signed by 49 academicians, said: «In the person of Ivan *Gavrilovich, the Academy of Sciences has lost one of its active members, a man of wide scope and bold initiative, comprehensively educated, who devoted all his strength to the socialist reconstruction of the country»*. Many Muscovites, who did not know Alexandrov personally, came to say goodbye to the famous author of the DneproGES. Academician Alexandrov was buried at the Novodevichy Cemetery.

Ivan Gavrilovich did not leave any diaries or notes about his many years of work, about frequent trips to various parts of the USSR and abroad, about meetings with leading scientists, engineers, and production workers. Most of the letters he wrote in different years perished during the war. The scientific profile of Alexandrov does not fit into the framework of a narrow specialty. Such a picture emerges with almost all really great scientists. He is considered «their own» by engineers, physicists, economists, geographers… That is why it is so difficult to characterise his scientific appearance in a short article [14; 6, pp. 510–512].

REFERENCES

1. Fainboim, I. B. Ivan Gavrilovich Alexandrov. Moscow, Gosenergoizdat publ., 1955, 136 p.

2. Krivoshein, G. G. Bridges from an artistic point of view. A separate print from the journal «Zodchiy» [*Mosty s khudozhestvennoi tochki zreniya. Otdelniy ottisk iz zhurnala «Zodchiy»*»]. St. Petersburg, Printing house of St. Petersburg City Administration, 1899, 16 p. [Electronic resource]: https://yadi.sk/i/6IMvYz5ckKuBX. Last accessed 24.10.2022.

3. Shchusev, P. V. Bridges and their architecture [*Mosty i ikh arkhitektura*]. Moscow, State publishing house for construction and architecture, 1953, 294 p. [Electronic resource]: http://science.totalarch.com/book/0283.rar. Last accessed 24.10.2022.

4. Artemov, A. A., Barinov, A. A., Bogdan, A. T. [*et al*]. MIIT at the turn of the century [*MIIT na rubezhe vekov*]. Ministry of Railways of Russia, Moscow State University of Railway Engineering (MIIT). Ed. by B. A. Lyovin. Moscow, MIIT publ., 2002, 639 p. ISBN 5-7876-0015-0.

5. Alexandrov Ivan Gavrilovich. Great Soviet Encyclopedia, 3rd ed. Chief ed. A. M. Prokhorov. Vol. 1. Moscow, Soviet Encyclopedia, 1969, p. 413. [Electronic resource]: https://slovar.cc/enc/bse/1971519.html. Last accessed 24.10.2022.

6. Alexandrov Ivan Gavrilovich // Railway transport. Encyclopedia. Chief ed. N. S. Konarev. Moscow, Scientific publishing house «Big Russian Encyclopedia», 1994, 560 p. **ISBN** 5-85270-115-7.

7. Report to 8th Congress of Soviets of the State Commission for Electrification of Russia (GOELRO plan). Moscow, Gospolitizdat publ., 1955, 660 p. [Electronic resource]: https://omskmark.moy.su/publ/essayclub/noobiblion/2015_goelro_1920_1955/111–1–0–2622. Last accessed 24.10.2022.

8. Alexandrov, I. G. Economic zoning of Russia [*Ekonomicheskoe raionirovanie Rossii*]. In.: Proceedings of 8th All-Russian Electrotechnical Congress in Moscow October 1–10, 1921. Iss. 2 Electrification of districts. Moscow, Gosudarstvennaya obshcheplanovaya komissiya, 1921, pp. 7–23. [Electronic resource]: http://elib.shpl.ru/ru/nodes/35415. Last accessed 24.10.2022.

9. Alexandrov, I. G. Dnieper rapids [*Dneprovskie porogi*]. *Tekhniko-ekonomicheskiy vestnik*, 1921, Iss. 1, pp. 9–18.

10. Development of the electric power industry of the USSR. Chronological index [*Razvitie elektrotekhnicheskogo khozyaistva SSSR. Khronologicheskiy ukazatel*]. Moscow, Energoatomizdat publ., 1987, 144 p.

11. Electrification of the USSR. 1912–1967 [*Elektrofikatsiya SSSR. 1912–1967*]. Ed. by P. S. Neporozhniy. Moscow, Energia publ., 1967, 542 p.

12. Electrification of the USSR [*Elektrofikatsiya SSSR*]. Ed. by P. S. Neporozhniy. Moscow, Energia publ., 1970, 543 p.

13. Alexandrov, I. G. Dnieper construction and its economic significance [*Dneprovskoe stroitelstvo i ego ekonomicheskoe znachenie*]. Kharkiv, State publishing house of Ukraine, 1925, 47 p. [Electronic resource]: http://gpntb.dlibrary.org/ru/nodes/1581-aleksandrov-i-g-dneprovskoe-stroitelstvo-i-ego-ekonomicheskoe-znachenie-harkov-1925. Last accessed 24.10.2022.

14. Malyshev, V. M. Angara problem [*Problema Angary*]. Moscow-Irkutsk, East Siberian regional publishing house, 1935, 121 p. [Electronic resource]: https://npp-geotek.com/upload/iblock/0cc/0cc4f2407d58121829f01ed190e4dd91.pdf. Last accessed 24.10.2022. ●

Information about the author:
Grigoriev, Nikolay D., *Ph.D. (Eng), Moscow, Russia, 9165688074@yandex.ru.*

Article received 02.10.2022, approved 28.11.2022, accepted 05.12.2022.