ORIGINAL ARTICLE
DOI: https://doi.org/10.30932/1992-3252-2021-19-6-11

World of Transport and Transportation, 2021,
Vol. 19, Iss. 6 (97), pp. 218–227

The History of Development of Inland Transport Infrastructure: Technology and Economic Aspects. Part 1

Aleksey D. RAZUVAEV

Aleksey D. Razuvaev
Russian University of Transport, Moscow, Russia.
✉ *razuvaevalex@yandex.ru.*

ABSTRACT

The article, consisting of two parts, studies historical and economic aspects, physical infrastructure and technological basis of emergence, formation, and evolutionary development of inland transport infrastructure. In contrast to water and air transport, land transport, due to its linkage to a certain territory, developed in a very restrained and nonlinear manner. Its infrastructure, represented by the simplest paths and roads, of course, played a certain economic role, but until 18th–19th centuries was not considered as the basis for regular advance and exchange of goods. In different parts of the world, the infrastructure of land transport developed differently which was largely due to the prevailing socio-economic institutions.

For many centuries, the technical condition of the inland transport infrastructure and its economic importance have not undergone any significant changes. Therefore, the end of the medieval era and a significant breakthrough in development of land transport are interdependent processes. The emergence of an era of economic growth, including development of international trade and an increase in social welfare, would not have been possible without a well-functioning land transport system. Nevertheless, land transport until the beginning of 19th century was not associated with a reliable, fast, and regular medium of exchange and travel. Only with the advent of railways the situation changed radically. Paved roads were also developing. From this moment land transport and its infrastructure has become the basis of the dynamic economic activity of society.

Keywords: *land transport, railways, railway infrastructure, socio-economic development, economic history, historical analysis.*

For citation: *Razuvaev, A. D. The History of Development of Inland Transport Infrastructure: Technology and Economic Aspects. Part 1. World of Transport and Transportation, 2021, Vol. 19, Iss. 6 (97), pp. 218–227. DOI: https://doi.org/10.30932/1992-3252-2021-19-6-11.*

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.

INTRODUCTION

Birth of Formation of Land Transport Infrastructure

The land transport infrastructure has been known since ancient times. A trail or dirt road is the simplest object of transport infrastructure. Over the course of several thousand years, roads have evolved significantly, turning into sophisticated engineering systems that are arteries for trade and movement of people. The economic significance of land transport is very high since penetrating to any point on the continent, it «compresses» distances and creates the most favourable conditions for exchanges and division of labour. Land transport and its infrastructure are also unique in that they must compete with other modes of transport, which are water and air ones, in unequal conditions since they need to create an artificial route. It is one of the reasons why, until 18th–19th centuries, transportation by land was a daunting task. Only with the advent of vehicles running on rails (railways) land transport was able to compete with water transport and became the main catalyst for the era of modern economic growth.

Indeed, it is worth noting that since ancient civilisations, in Mesoamerica, on the Mayan lands, there was an extensive road network – *sakbé* («white road», a stone-paved road) (Pic. 1). Its development attracted special attention despite the dominance water transportation and the absence of draft animals [1].

Similarly, development of roads took place in the early period of the existence of the Andean civilisation, in 1st–2nd centuries B.C. Then the well-being and socio-economic status of the province depended on availability of a road [2, p. 261]. By the middle of the 1st millennium A.D. a network of main routes had been developed in the Andes. It was not the network of trails but of well-maintained roads equipped with caravan terminals, along which caravans of many hundreds of lamas were driven. Due to this, the Andean civilisation developed specialisation and settlements arose [3].

The longest of the Inca roads was over 5 thousand km. This is twice the length of the famous Royal Road, the main land route of the Persian Empire. According to some estimates, the total length of the improved paths of the Incas reached 30 thousand km. This means that the provision of both the territory and the population with inland infrastructure then exceeded the level of the Roman Empire, which can be considered the standard of transport development (especially of land transport) in the Ancient world. And in Europe at the time of the Inca Empire, there were no roads that would have been close in terms of improvement to the Inca ones. In many ways,

Pic. 1. Sakbé. A stone-paved road. (Sakbe – mysterious ancient maya roads. [Electronic resource]: https://zen.yandex.ru/media/chronoton/sakbe-zagadochnye-drevnie-dorogi-maiia-5df0b53eb477bf00af8391ef. Last accessed 11.06.2021).

Pic. 2. A section of the Royal Road that has survived to this day. (Persian state: history of origin, life and culture. [Electronic resource]: https://autogear.ru/article/165473/persidskaya-derjava-istoriya-vozniknoveniya-byit-i-kultura. Last accessed 11.06.2021).

an extensive network of roads contributed to unification and unity of the Inca Empire [2, p. 263; 4].

The Assyrian and Persian empires carried out a large-scale arrangement of overland transport ways in the East [5].

The Persian Empire, which united almost the entire Ancient East, created a unique road network. Improved roads crossed the country in different directions. The previously mentioned Royal Road had a length of almost 2 thousand km (Pic. 2).

The Greeks also had good roads, which served, however, mainly to get to the sacred places. The experience of Greece in creation of track ways is noteworthy. The most famous is the diolkos, a track portage road along the Corinth Canal (Pic. 3). Also, in Ancient Greece, the track was used for various needs, when there was a need to transport heavy loads over a short distance[1] [6, p. 9; 7].

The Roman state (in the republic, and then in the Empire), which became the successor of the Hellenistic world in the Mediterranean, created a powerful road network, which, as in the Persian Empire, was primarily of military-strategic importance, but, naturally, facilitated trade relations and travelling [8–10].

We can say that the Roman state developed together with the development of the road network. The first ancient Roman paved road, Appian Way, 62 km long, was built at the end of 4th century B.C. (Pic. 4).

Five centuries later, during the period of the mighty power of the Roman state, which had already become an Empire and subjugated not only the entire Mediterranean region, but also several remote lands, there were 372 stone-paved roads with a total length of about 80 thousand km. These roads were built in a straight line, drainage ditches were dug on their sides, bridges were thrown across rivers and ravines, some of which have survived to our time.

The zeal of the Roman Empire in road construction was very significant and was supported by various social institutions and advanced engineering thought [11, p. 179–180]: «*Roads in ancient societies were most often ground-coated, and at different times of the year they turned into swampy ditches or dusty paths. The Romans, starting with the Via Appia from Rome to Capua in 312 B.C., put a tremendous amount of work and organisational effort into creating an extensive paved road network. Perfect Roman viae*[2] *consisted of layers of gravelly concrete, cobblestones, or mortar-anchored stone slabs. By the reign of Diocletian (285–305), the Roman road system*

[1] Track roads of Ancient Greece. [Electronic resource]: https://aldanov.livejournal.com/364552.html. Last accessed 11.06.2021.

[2] Roads *(lat.)*.

Pic. 3. Groove for transporting heavy loads (Diolkos. [Electronic resource]: https://ru.wikipedia.org/wiki/Диолк. Last accessed 11.06.2021).

Pic. 4. Section of the Appian Way (modern view). (Appian Way. [Electronic resource]: https://a-dedushkin.livejournal.com/630813.html/. Last accessed 11.06.2021).

Pic. 5. Artistic illustration of the technology of building Roman roads with layer-by-layer detailing of masonry (How Roman roads were built. [Electronic resource]: https://pikabu.ru/story/kak_stroilis_rimskie_dorogi_5870592. Last accessed 11.06.2021).

(cursus publicus) had grown to 85 thousand kilometres. <…> In Western Europe, Roman achievements in road construction were surpassed only in 19th century, and in the eastern regions of the continent – only in 20th» (Pic. 5).

Labour costs for construction of Roman roads are analysed in detail in [11, p. 180]. It provides data that, based on the need for building materials and labour costs for construction of the road, an amount of 1,2 billion workdays can be obtained (this amount is made up of the following boundary conditions: with a roadway width equal to 5 m and a depth equal to 1 m, as well as a length of ~85 thousand km, the initial earthwork is taken equal to 800 Mm^3, and the subsequent work on displacement of building material are considered equal to 425 Mm^3. If a single worker copes with 1 m^3 of material per day, a total value of 1,2 billion workdays is obtained). Even if continuous maintenance and repair of roads will triple this figure, its proportional distribution over 600 years of construction will result in an annual average value of about 6 million workdays, which is the equivalent to work of 20 thousand builders (with an approximate number of 300 working days per year).

Roman roads, given the scale of construction, the cost of energy, time, material and labour, can be safely attributed to one of the wonders of the world. The speed of movement along them and the volume of transportation by land were at that time the most developed, given that the speed of information transfer from Antiquity to the end of the Middle Ages was almost unchanged and amounted to about 1 mile per hour [12, p. 253].

Then long distances were covered by messengers on fastest horses: the recorded maximum for Roman roads was about 380 km/day [11, p. 180].

Freight transportation by land was poorly developed. The low speeds and small capacity of land transport led to high costs. In 301, transporting grain for 120 km by road costed more than transporting it by ship from Egypt to Ostia, the sea gate of the Roman Empire [11, p. 182].

On the territory of the Muslim world, there was nothing comparable to Roman roads, although communications were intense. Cities and countries far removed from each other were connected by caravan routes and ways, which were technically just paths [11, p. 180].

The work [11, p. 181] noted about the previously mentioned history of creation of the road network of the Inca Empire, which had a considerable length, but on which wheeled transport was not used: «*The Incas, strengthening their Empire in 13th–14th centuries, built an impressive network of roads. <…> Their total length reached about 40 thousand kilometres, including 25 thousand kilometres of all-weather roads crossing drainage pipes and bridges and equipped with distance indicators. Of the two main royal roads, one, winding through the Andes, was paved with stones. Its width varied from 6 meters on river terraces to only 1,5 meters*

where it went over the rocks. The unpaved road near the coast was 5 meters wide. The roads of the Incas were not intended for wheeled transport, only caravans of people and pack lamas moved along them, carrying 30–50 kg of cargo per animal and passing less than 20 km/day». At the same time, K. Marx noted that «*…in the kingdom of the Incas, the transport industry played an important role, although the social product was not circulated as a commodity, was not distributed through exchange trade*» [13].

In China, during the reign of Qin and Han dynasties, an extensive system of roads with a total length of about 40 thousand kilometres was built. The Roman road network, created around the same time, had a greater length and road density per unit area, and had better pavement.

The infrastructure of land transport in the Middle Ages not only did not receive further development but was destroyed. The socio-economic processes taking place in Europe, in particular the raids of the powerful barbarian tribes and naturalisation of the economy, threw the infrastructure of the road network back to the period before the ancient era [8].

The first victims of the decline and collapse of the trading system of ancient times were Roman roads. At the same time, the medieval roads that appeared later, from a material point of view, were not so much roads as ways [14, p. 36].

The roads were practically not built or maintained [15]: «*Almost all land roads were unpaved, which made it extremely difficult or even impossible to use them during the spring and autumn muddy seasons. Moreover, they were often so narrow that two carts could not part. The surviving sections of the paved ancient Roman roads were often dismantled by the neighbouring residents to get stones for their needs*».

«*The medieval road was depressingly long and slow*». Daily journeys «*varied depending on the nature of the terrain from 25 to 60 km*» [14, p. 166].

It was not possible to completely destroy the Roman road network, which is why Byzantium, which inherited the network of land roads and seaports from the Roman Empire, began to play a key role in trade between East and West.

The key event that determined formation of the modern infrastructure of land transport was creation of an artificial way, which later evolved into a railroad track.

Evolutionary Development of Land Transport Infrastructure

The development of the road network and of vehicles are closely related to each other, so closely that improvement of vehicles depends on the quality of the road surface, i.e., quality of the road infrastructure [16]. For example, in England during the reign of Charles I, movement of stagecoaches on public roads was prohibited for some time to protect them from deterioration. But there was also a stricter prohibition. The law limited the minimum width of the iron carriage cover (up to 40 mm). At the same time, broad-wheeled vehicles were even exempted from tax at the outposts [17, p. 232].

In terms of quality of pavements, France was in the lead just before the industrial revolution, introducing new types of paving and reducing tariffs for current maintenance. In the middle 17th century, special organisations for current maintenance of road surfaces began to appear in Great Britain: road trusts, the prototype of modern infrastructure companies. Before them, the maintenance of roads was carried out by the residents of the district where the road passed [17, p. 477].

The evolution of road paving in Great Britain made it possible in 1832 (just during the massive use of carriages) to increase the average speed to 15 km/h, and the London–Edinburgh route, which until 1776 had taken four days, could be overcome in 42,5 hours. D. L. Macadam's paving technology has become the most applicable in the world largely due to simple solutions and low construction costs (Pic. 6) [17, p. 480].

With the increase in traffic intensity, paved surfaces were replaced by asphalt concrete ones. In 17th and early 18th centuries, a railroad appeared in England, which, in its most primitive form, had existed at German mines already 30–60 years before. First, a guide pin was placed on the trolley, moving along the chute, and then wooden flanged wheels were used (Pics. 7, 8) [17, p. 233].

The British first used rails in 1597–1598 in coal mines. The trolley wheel was rolling in a groove along the slopes, according to the principle of movement along an antique track road, but then the shape of both the rail and the wheel changed. Originally the rails were made of wood. In 1767, the first metal rails were manufactured for a metallurgical plant in

Pic. 6. Country road built using Macadam's technology (Macadam. [Electronic resource]: https://en.wikipedia.org/wiki/Macadam. Last accessed 11.06.2021).

Coalbrookdale [17, p. 234]. Then, within ten years, wooden rails were replaced with iron ones within the entire factory rail system (its length was 16 miles, about 26 km).

The emergence of railways is due to two macro-inventions: smelting of relatively cheap cast iron and emergence of a steam engine [12, p. 253].

The world's first public railway with steam traction was built in England by George Stephenson in 1825, it ran between Stockton and Darlington[3] [18]. On September 27, the steam «Lokomotiv» pulled a train of 34 cars, including 28 cars with 400 passengers, at a speed of up to 24 km/h. In 1830, according to Stephenson's project, Liverpool–Manchester railway with a length of about 50 km was built and put into operation [19, p. 28].

Speaking about the first railway lines, one cannot fail to note Middleton railway, the world's oldest public railway, operating without interruptions since 1758. It went all the way of early evolution – from horse tram and cast-iron rails to cogwheel rail and steam. Initially, it was operated as an industrial, and then as a commercial one[4].

At that time, large-scale earthworks, drainage of swamps, the need to comply with a minimum longitudinal gradient and overcoming natural obstacles (rivers, gorges, mountains) became the distinctive features of road (highway), and then railway construction. In this regard, starting from 18th century, bridge construction entered a new round of development. The bridges of Jean-Rodolphe Perrone (France), Robert Mylne, John Rennie, Abraham Darby, Thomas Telford (all Great Britain), Dmitry Zhuravsky (Russian Empire) are known [17, p. 498–508].

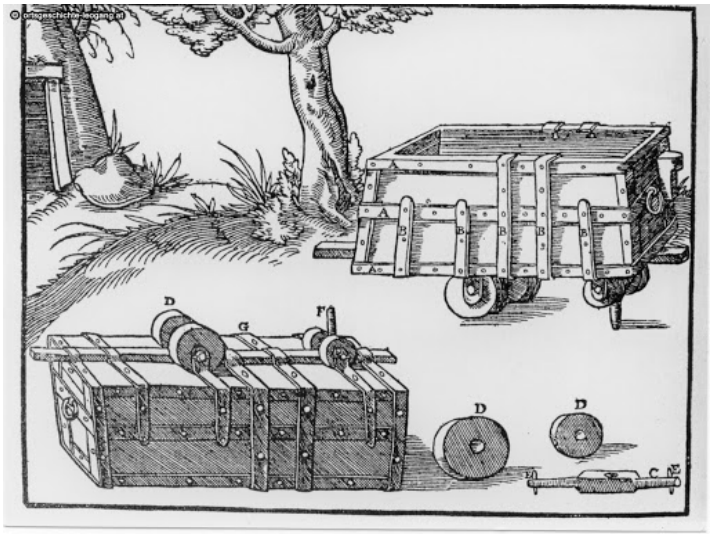
Tunnelling, previously actively used only for the mining industry, attained new level. In 1830, a tunnel section of the railway to Liverpool was built. Tunnels were laid under the Thames (Tower Tunnel, 1869), and in the Alps at the end of 19th century–the beginning of 20th century (Mont-Cenis, Saint Gotthard, Simpion) [17, p. 508–514].

Infrastructure restrictions remained in many countries until 18th century [11, p. 182]: «*For example, at the beginning of the century it was cheaper to deliver certain goods to England by sea from Europe than to bring them by land from remote regions of the country. Travelers described the condition of British roads as barbaric, disgusting, vile and hellish*».

The roads in continental Europe were no better. Fundamental improvements in road infrastructure did not begin until after 1750. At first, these included widening roads and ensuring good water drainage, and later – creating and strengthening the pavement with more durable materials (gravel, asphalt, concrete). By the middle of 19th century, the maximum cargo allowed for transportation in France increased to almost 1,4 tons, four times more than in Roman times [11, p. 182].

[3] Stockton-Darlington railway. [Electronic resource]: https://ru.wikipedia.org/wiki/Железная_дорога_Стоктон_—_Дарлингтон. Last accessed 11.06.2021.

[4] Middleton railway. [Electronic resource]: https://ru.wikipedia.org/wiki/Мидлтонская_железная_дорога. Last accessed 11.06.2021.



Pic. 7. Wooden trolley with a guiding axle pin. (Minecart. [Electronic resource]: https://en.wikipedia.org/wiki/Minecart. Last accessed 11.06.2021).

Pic. 8. Wooden trolley on wooden guides (beds) with wheels with flanges. (History of railway transport. [Electronic resource]: https://ru.wikipedia.org/wiki/История_железнодорожного_транспорта. Last accessed 11.06.2021).

The notes of domestic travellers who covered considerable distances in the era before the railways, likewise, are replete with many unflattering reviews about the road infrastructure. The roads of acceptable quality existed only in the western part of the Russian Empire, besides, among them there were only a few routes that made it possible to travel by wheeled transport without many hours or even multi-day stops (roads from St. Petersburg to Moscow, to Pskov, to Novgorod). A. S. Pushkin, A. N. Radishchev, the English scientist W. Cox, the Hanoverian resident at the Russian court F. H. Weber, the honorary surgeon and personal physician of Alexander I D. K. Tarasov and many others wrote about the inconveniences of travelling. Nevertheless, the passion for travel among Russian writers, poets and artists did not fade away, but with the advent of railways, on the contrary, began to manifest itself to a greater extent, as evidenced by their publication activity and involvement in transport topics [20–22].

Regarding development of railways, it is worth noting that [11, p. 236]: «*Starting with the first intercity branch at 56 km (Liverpool–Manchester) in 1830, British railways stretched up to 30 thousand km by 1900, in Europe the total length of railways was 250 thousand km.*

Worldwide, the most powerful expansion of railways was observed in the last three decades of 19th century. By 1900, the network in Russia had reached 53 thousand km (but the Trans-Siberian Railway was completed to reach the Pacific Ocean only in 1917), in the USA at the same time there were more than 190 thousand km (including three transcontinental lines), and in total in the world (with most of the remaining railways in British India), there were 775 thousand km. As a result, the expansion of the rail network was the main reason for the unprecedented demand for steel in the second half of the century».

It should be noted as an interesting fact that in urban transport, the peak of the importance of horses fell on the era of steam locomotives, between the 1820s and the end of 19th century. While railways carried long distances, traction transport began to dominate all fast-growing cities in Europe and North America, carrying for short distances. The era of steam engines increased the use of horses. Thus, cargo for the railways had to be collected and brought to the station on horse-drawn carts. It was not possible to do without them even when delivering food and raw materials from the suburbs [11, p. 182]. Soon, at the end of 19th century, with development of electricity and the internal combustion engine, trams and cars began to displace carriages from the roads.

The construction of railways developed at an unprecedented pace, changing the appearance of cities and countries, influencing the life of people [11, p. 314]: «*Railways have transformed the transport system in just decades. Due to them, not only did the space shrink and change its configuration, the level of comfort for travellers also increased. The mile per minute (96 km/h) was first reached for a short time by an ordinary English train in 1847; this year is also marked by some of the greatest railroad activity in the UK, with a dense new transport network in just two generations*».

Having set the pace, Britain began to lose leadership in the speed and extent of railway construction, but continued construction in the colonies. The USA and Russia were active successors of British building traditions [11, p. 314]: «*The total length of British railways was soon surpassed by the American ones, which began to be built in 1834 in Philadelphia. By 1860, the United States had 48 000 km of track, three times that of the United Kingdom. By 1900, the difference had increased almost tenfold. The first transcontinental line was completed in 1869, and by the end of the century four more such lines were built. In Russia, railway transport also developed very quickly: by 1860 there were less than 2 thousand km of tracks, but the figure had grown to more than 30 thousand by 1890 and to almost 70 thousand in 1913. The construction of a transcontinental line across Siberia to Vladivostok began in 1891 but was completed only in 1917. When the British left India in 1947, they left behind 54 000 km of railways (and 69 000 across the entire subcontinent). No other mainland country in Asia built railways on a significant scale prior to World War II*».

After the war, competition intensified from the part of new modes of transport: cars and airplanes. They diminished the relative importance of railways in most industrialised countries. Nevertheless, during the second half of 20th century, the USSR, Brazil, Iraq, and Algeria vigorously built new lines, and China became the leader in Asia (more than 30 thousand km were built between 1950 and 1990). And the most successful railway innovation of the post-war period was long-distance high-speed trains (Japanese *Shinkasen*). They began to operate in 1964 between Tokyo and Osaka and developed a maximum speed of 250 km/h. Today Japan is a country with more than half a century of experience in operating high-speed lines on an innovative basis [11, pp. 314–315; 23].

Since 1983, the French *trains a grand vitesse (TGV)* have been in operation. This is the first high-speed rail project in Europe, the speed limit of which implies a speed of up to 280 km/h. Similar high-speed lines exist in Spain (*AVE*), Italy (*Frecciarossa*) and Germany (*Intercity*). Over the past 20 years, China has set a new record for the total length of high-speed rail lines. In 2014, there were 16 thousand km of such roads, and in 2019 – more than 30 thousand km. For example, in the USA *Acela* (Boston–Washington, the average speed is only 100 km/h) is difficult even to be attributed as a modern high-speed train [11, p. 315; 24].

To be continued in one of the next issues.

REFERENCES

1. Ershov, G. G. Ancient America: flight in time and space. Mesoamerica [*Drevnyaya Amerika: polet vo vremeni i postranstve. Mezoamerika*]. Moscow, Aleteya publ., 2002, 392 p. [Electronic resource]: https://www.studmed.ru/view/ershova-gg-drevnyaya-amerika-polet-vo-vremeni-i-prostranstve-mezoamerika_3f6b48c64c2.html. Last accessed 11.06.2021.

2. Macheret, D. A. Socio-Economic Assessment of Transport on the Basis of Historical Comparisons. *World of Transport and Transportation*, 2016, Vol. 14, Iss. 1 (62), pp. 256–271. [Electronic resource]: https://mirtr.elpub.ru/jour/article/view/900. Last accessed 11.06.2021.

3. Berezkin, Yu. E. Inki. The historical experience of the empire [*Inki. Istoricheskiy opyt imperii*]. Leningrad, Nauka publ., 1991, 230 p. [Electronic resource]: https://www.studmed.ru/berezkin-yue-inki-istoricheskiy-opyt-imperii_1175325376a.html. Last accessed 11.06.2021.

4. Galich, M. History of pre-Columbian civilisations [*Istoriya dokolumbovykh tsivilizatsii*]. Trans. from Spanish. Moscow, Mysl publ., 1990, 407 p. [Electronic resource]: https://www.studmed.ru/galich-manuel-istoriya-dokolumbovyh-civilizaciy_df10f723a57.html. Last accessed 11.06.2021.

5. Lapidus, B. M., Macheret, D. A. Macroeconomic role of railway transport: Theoretical foundations, historical trends and a look into the future [*Makroekonomicheskaya rol zheleznodorozhnogo transporta: Teoreticheskie osnovy, istoricheskie tendentsii i vzglyad v budushchee*]. Moscow, Krasand publ., 2014, 234 p. ISBN 978-5-396-00528-0.

6. Zagorskiy, K. Ya. Transport economics [*Ekonomika transporta*]. Moscow–Leningrad, Gosizdat publ., 1930, 368 p. [Electronic resource]: https://www.studmed.ru/zagorskiy-k-ya-ekonomika-transporta_77670b556c4.html. Last accessed 11.06.2021.

7. Lewis, M. J. T. Railways in the Greek and Roman world. Eds. J. Rees. A Selection of Papers from the First International Early Railways Conference, 2001, pp. 8–19. [Electronic resource]: https://pdfslide.net/documents/railways-in-the-greek-and-roman-worlds.html. Last accessed 11.06.2021.

8. Macheret, D. A., Kudryavtseva, A. V., Ledney, A. Yu., Chernigina, I. A. General technical and economic course of railways [*Obshchiy tekhniko-ekonomicheskiy kurs zheleznykh dorog*]. Moscow, MIIT publ., 2017, 364 p. [Electronic resource]: https://www.twirpx.club/file/3022625/. Last accessed 11.06.2021.

9. Sotnikov, E. A. World railways from 19th to 21st century [*Zheleznie dorogi mira iz XIX v XXI vek*]. Moscow, Transport publ., 1993, 200 p. [Electronic resource]: https://www.studmed.ru/sotnikov-ea-zheleznye-dorogi-mira-iz-xix-v-xxi-vek_c666f295dd1.html. Last accessed 11.06.2021.

10. Sotnikov, E. A. History and prospects of world and Russian railway transport (1800–2100) [*Istoriya i perspektivy mirovogo i rossiiskogo zheleznodorozhnogo transporta (1800–2100)*]. Moscow, Intext publ., 2005, 112 p. ISBN 5-89277-060-5.

11. Smil, V. Energy and civilization. Trans. from English by D. L. Kazakov. Moscow, Eksmo publ., 2020, 480 p. ISBN 978-5-04-101573-2.

12. Macheret, D. A., Valeev, N. A., Kudryavtseva, A. V. Formation of the railway network: diffusion of epoch-making innovation and economic growth [*Formirovanie zheleznodorozhnoi seti: diffiziya epokhalnoi innovatsii I ekonomicheskiy rost*]. *Ekonomicheskaya politika*, 2018, Vol. 13, Iss. 1, pp. 252–279. DOI: 10.18288/1994-5124-2018-1-10. [Electronic resource]: https://www.elibrary.ru/item.asp?id=32655127. Last accessed 11.06.2021.

13. Marx, K. Capital. Complete quintessence of 3 volumes. Trans. from German by S. Alekseev; comp. and foreword. By Yu Borchardt. Moscow, AST publ., 2019, 352 p. [Electronic resource]: https://royallib.com/read/marks_karl/kapital_polnaya_kvintessentsiya_3h_tomov.html#0. Last accessed 11.06.2021.

14. Le Goff, J. Civilization of the Medieval West. Trans. from French by V. A. Babintseva after. by A. Ya. Gurevich. Yekaterinburg, U-Factoria publ., 2005, 560 p. ISBN 5-9709-0037-0. [Electronic resource]: https://booksprime.ru/books/civilizaciya-srednevekovogo-zapada/. Last accessed 11.06.2021.

15. Macheret, D. A. Socio-economic role of transport in the Middle Ages. *World of Transport and Transportation*, 2015, Vol. 13, Iss. 2 (57), pp. 228–237. [Electronic resource]: https://mirtr.elpub.ru/jour/article/view/289. Last accessed 11.06.2021.

16. Melnikov, A. History of the wheel. From potter's wheel to airliner landing gear [*Istoriya kolesa. Ot goncharnogo kruga do shassi avialainera*]. Moscow, Tsentrpoligraf publ., 2021, 351 p. ISBN 978-5-227-09364-6.

17. Derry, T., Williams, T. A Brief History of Technology. Ideas, processes and devices with the help of which a person changes the environment from antiquity to the present day. Trans. from English by A. A. Ilyin. Moscow, CJSC Tsentrpoligraf publ., 2019, 488 p. [Electronic resource]: https://obuchalka.org/20210724134561/kratkaya-istoriya-tehnologii-derri-t-uilyams-t-2019.html. Last accessed 11.06.2021.

18. Levin, D. Yu. History of railway transport: Study guide [*Istoriya zheleznodorozhnogo transporta: Ucheb. posobie*]. Rostov-on-Don, Phoenix publ., 2018, 414 p. ISBN 978-5-222-28294-6.

19. History of railway transport in Russia [*Istoriya zheleznodorozhnogo trasnporta Rossii*]. Vol. 1: 1836–1917. St. Petersburg, 1994, 336 p. ISBN 5-85952-005-0. [Electronic resource]: https://bookree.org/reader?file=638029&pg=6. Last accessed 11.06.2021.

20. Vulfov, A. History of the railways of the Russian Empire [*Istoriya zheleznykh dorog Rossiiskoi imperii*]. Moscow, Ripol Classic publ., 2016, 744 p. ISBN 978-5-386-08589-6. [Electronic resource]: https://fb2lib.ru/obshchie-raboty-po-istorii-rossii/istoriya-zheleznykh-dorog-rossiyskoy-imperii/. Last accessed 11.06.2021.

21. Pavlov, A. From St. Petersburg to Pskov in the era before the railways. On the history of communication lines in Russia in 18th–19th centuries [*Iz Peterburga v Pskov v epokhu do zheleznykh dorog. K istorii putei soobscheniya v Rossii XVIII–XIX stoletii*].St.Petersburg, Nestor-Istoriya publ., 2020, 144 p. ISBN 978-5-4469-1021-2.

22. Razuvaev, A. D. Sovremennik Magazine about the Railways (socio- economic analysis) *World of Transport and Transportation*, 2020, Vol. 18, Iss. 2 (87), pp. 260–269. DOI: https://doi.org/10.30932/1992-3252-2020-18-260-269.

23. Tsypin, P. E., Razuvaev, A. D. Modern trends in development of railway infrastructure [*Sovremennie tendentsii razvitiya infrastruktury zheleznykh dorog*]. *Collection of scientific papers* «*Actual problems of economic and financial management of transport companies*». Moscow, Art-Business Center, 2016, pp. 182–187. [Electronic resource]: https://lektsii.org/7-79925.html. Last accessed 11.06.2021.

24. Razuvaev, A. D. Methodology for assessing the missed effects of distancing the construction of high-speed lines [*Metodologiya otsenki upushchennykh effektov ot otdaleniya stroitelstva VSM*]. *Ekonomika zheleznykh dorog*, 2019, Iss. 12, pp. 30–39. [Electronic resource]: https://elibrary.ru/item.asp?id=41509420. Last accessed 11.06.2021. ●

Information about the author:

Razuvaev, Aleksey D., *Ph.D. (Economics), Associate Professor at the Department of Economics of Transport Infrastructure and Construction Business Management of Russian University of Transport, Moscow, Russia, razuvaevalex@yandex.ru.*

Article received 11.06.2021, approved 06.09.2021, accepted 22.10.2021.