LYTVYNENKO, A., SARANCHA, V. and SHABUNINA, V. 2021. MAN trolleybuses in Ukraine (1939-1951): a history, technical characteristics, features of operation. *History of science and technology* [online], 11(2), pages 411-436. Available from: https://doi.org/10.32703/2415-7422-2021-11-2-411-436

MAN trolleybuses in Ukraine (1939-1951): a history, technical characteristics, features of operation.

LYTVYNENKO, A., SARANCHA, V. and SHABUNINA, V.

2021

DOI: 10.32703/2415-7422-2021-11-2-411-436

UDC 629.34:94(85).083:94(477)

Anatoliy Lytvynenko
Baltic International Academy
4, Lomonosova Street, Riga, Latvia
Ivan Franko National University of Lviv
1, Universytetska Street, Lviv, Ukraine, 79000
Robert Gordon University
Garthdee House, Garthdee Road, Aberdeen, AB10 7QB, Scotland, United Kingdom
e-mail: anat.lytvynenko@gmail.com
https://orcid.org/0000-0001-7410-5292

Viktor Sarancha
Kremenchuk Mykhailo Ostrohradskyi National University
20, Pershotravneva Street, Kremenchuk, Ukraine, 39600
e-mail: visar73@ukr.net
https://orcid.org/0000-0001-9435-0615

Viktoriia Shabunina
Kremenchuk Mykhailo Ostrohradskyi National University
20, Pershotravneva Street, Kremenchuk, Ukraine, 39600
e-mail: shabuninaviktoria@gmail.com
https://orcid.org/0000-0001-7957-3378

MAN trolleybuses in Ukraine (1939–1951): a history, technical characteristics, features of operation

Abstract. *The growth of the vehicle assets and bus services in Ukrainian cities increases the level of environmental pollution. During the environmental crisis, electric transport (e-transport) is becoming a matter for scientific inquiry, a subject of discussion in politics and among public figures. In the program for developing the municipal services of Ukraine, priorities are given to the development of the infrastructure of ecological transport: trolleybuses, electric buses, electric cars. The increased attention to e-transport on the part of the scientific community, politicians, and the public actualizes the study of its history, development, features of operation, etc. The historiographic analysis carried out by the authors allows us to say about insufficient coverage by Ukrainian researchers of a number of aspects and periods in the history of e-transport. A small number of special works on the history of the operation of foreign-made trolleybuses in Ukrainian cities in the first half of the 20th century and an analysis of their technical characteristics determine the relevance and*

scientific novelty of this study. When writing the work, Ukrainian and foreign scientific reference publications, monographs, papers, mainly from foreign electronic resources, have been used. The authors have used both general scientific (analysis, synthesis, deduction, induction) and historical research methods, in particular, problem-chronological, comparative-historical, retrospective methods, etc. The aim of the study is to highlight little-known facts of the history of production and operation of MAN trolleybuses in Ukrainian cities, as well as to introduce their technical characteristics into scientific circulation. The etymology of the model names of German trolleybuses, which usually consisted of the names of the manufacturers of chassis, body, and electrical equipment, has been clarified. The types, specific design solutions of the first MAN trolleybus generation and the prerequisites for their appearance in Chernivtsi have been determined. Particular attention has been paid to trolleybuses that were in operation in Germany and other Western European countries from the first half of the 1930s to the early 1950s. In the mid-1930s, the MAN plant in Nuremberg began production of trolleybuses; its models had the most modern constructive solutions at that time, a characteristic design and a state-of-the-art heating system. Depending on the length, German manufacturers divided the trolleybus models into four types. As a result of problems with the operation of the bus fleet in Chernivtsi, the city authorities have decided to build a trolleybus line in the city; four trolleybuses manufactured by the MAN plant were purchased. The paper traces the stages of operation of the MAN trolleybuses in Chernivtsi, where they worked during 1939–1944 and after the end of the Second World War, they were transferred to Kyiv. After two years of operation in the Ukrainian capital, the trolleybuses entered the routes in Dnipropetrovsk during 1947–1951. The technical characteristics of the first MAN trolleybus generation, which were operated in Ukrainian cities, have been presented and analyzed. It was determined that in all the main indicators and operational parameters, they were as close as possible to similar models of German trolleybuses. The proposed methodology and the structure of the study can later be used to write papers on the history of science and technology, in particular, of an e-transport.

Keywords: *electric transport; trolleybus; operation; machine; Chernivtsi; Germany*

Introduction.

Public transport and municipal transport-and-road infrastructure play an extremely important role in the development of modern cities. Public transport significantly improves the quality of life in urban agglomerations, provides reliable, efficient, and cost-effective passenger service. It serves the interests of both individual citizens and the entire population of the city, expands individual opportunities and provides personal mobility.

In the context of the environmental crisis accompanied by the deterioration of the health of the world's population, the priority direction of the UN Environment Program is the development of an environmentally friendly transport. The critical state of the

technological infrastructure in Ukraine threatens the socioeconomic development of the State, deepens environmental problems, and creates a negative image in the eyes of Western investors. In order to improve the situation under the National Transport Strategy by 2030, Ukraine plans to completely replace all urban public transport with an electric one and to create the appropriate infrastructure for this. So, in November 2020, V. Kryklii, Minister of Infrastructure, stressed that the government will continue to support the use of ecological modes of transport in cities, in particular an urban electric one and electric cars (Kabmin planuie..., 2020).

As of 2021, 42 trolleybus systems, by the number of which the State ranks second in the world, operate in Ukraine. The environmental friendliness and economy of this type of transport make it attractive for the transformation of an urban transport infrastructure. At the same time, problems that hinder the intensive development of trolleybus services are the obsolescence of rolling stock in most Ukrainian cities and competition with trams and subway in metropolises. In this regard, the study of the history of the trolleybus transport functioning in the cities of Ukraine and the technical features of its individual models is an urgent scientific problem.

Analysis of the latest research, which laid the foundation for solving the problem.

Modern historiography of e-transport can be divided into such components as studios on the general and Ukrainian history of e-transport, regional and local studies, in particular "Istoriia lvivskoho tramvaia" (Tarkhov, 1994), "Istoriia miskelektrotransportu Chernivtsiv" (Tarkhov, 1997a), "Pervyj v Krymu: Istoriya tramvaya i trolleybusa v Sevastopole" (Tarkhov, 1998), "Kyivskyi troleibus" (Kozlov & Mashkevych, 2009), etc. In addition to historical and regional studies, the problem of e-transport is present in works on economics, municipal management, papers in technical sciences, etc.

Among the editions of an encyclopedic nature, the encyclopedic guide, which became the first comprehensive study of the history of urban electric transport – a tram, a trolleybus, a subway, a funicular railroad – for the entire period of its existence in the cities of Ukraine, deserves attention (Tarkhov, Kozlov, & Olander, 2010). We should also mention the encyclopedia on the history of the trolleybus system in Germany – the trilogy "Obusse in Deutschland" (Kenning & Schindler, 2009), the materials of which were used in writing the work.

Ukrainian scientists S. S. Hutyria, D. M. Bordeniuk, and A. M. Chanchyn (2011) investigated and analyzed the technical evolution of trolleybuses produced by leading world and Ukrainian companies, identified trends in their technical level.

Much of the research at the local level is devoted to the history of the Kyiv trolleybus network, which became the first in the Ukrainian SSR. In particular, K. Kozlov and S. Mashkevych (2009) highlighted the history of the development of the trolleybus facilities in Kyiv, revealed the features of the creation and development of the trolleybus network, traced the evolution of the types of trolleybuses that in

different years run the streets of the capital of Ukraine. On the 75th anniversary of the launch of the trolleybus network, K. A. Bramskyi (2011, pp. 64–69) published a paper on the formation and development of the trolleybus network in Kyiv.

I. V. Kryvoviaziuk and S. O. Kraichuk (2016) analyzed the dynamics and structure of the sectoral passenger turnover in Ukraine, revealed the factors influencing the dynamics of the market situation in the bus and trolleybus construction market, characterized the bus and trolleybus construction market in Ukraine, identified the features of its functioning and further development.

Prospects and directions of development of the urban e-transport market in Ukraine, the state of its rolling stock was studied by O. M. Polinkevych (2019, pp. 120–124). The researcher identified the main manufacturers of e-transport in Ukraine, proposed the formation of a single carrier along urban routes, and substantiated the need to search for investments in order to finance programs for the development of e-transport in the context of a "smart city".

However, to date, no special studies on the history of operation of foreign-made trolleybuses in Ukraine with a description of their technical characteristics have been revealed.

For seventy years, more than twenty models of rolling stock of Ukrainian (for example, MTBES trolleybuses, various models of Kyiv and LAZ, machines of the Production Association Yuzhny Mashinbuilding Plant named after A. M. Makarov, State Enterprise, nowadays also Bogdan and Etalon), Russian (for example, MTB-82, ZiU trolleybuses), as well as foreign production (mainly Škoda trolleybuses) were in operation of the trolleybus facilities of Ukraine, in some cities, in particular Kharkiv – Rocar DAC). It should be noted that the MAN MPE I/MAN model went almost unnoticed. These are trolleybuses produced by the German machine-building enterprise Maschinenfabrik Augsburg & Nürnberg (MAN) in a small series of four cars, which became famous due to their operation in the cities of modern Ukraine— Chernivtsi, Kyiv, and Dnipro. All four vehicles were manufactured in the spring-autumn of 1938. Until the mid-2010s, these were the only MAN trolleybuses operating in Ukrainian cities. At the beginning of winter 2015, 29-year-old MAN SL 172 HO M12 vehicles were brought to Mariupol from Solingen (Germany).

For a long time, these trolleybuses remained one of the least known models of rolling stock operating on the roads of Ukraine, mainly due to a critical lack of information about their components and design features. Due to the efforts of historians, transport workers, and enthusiasts who have found their reflection in works such as "Kyivskyi troleibus" (Kozlov & Mashkevych, 2009), the history of these trolleybuses has been partially investigated, but information about the features of the MAN models is still lacking, and all technical details contain only specialized foreign literature.

The goal and objectives of the study.

The goal of the study is to highlight little-known facts of the history of production and operation of MAN trolleybuses in Ukrainian cities, as well as to introduce their technical characteristics into scientific circulation.

Achieving this goal requires solving the following research tasks:

– to find out the etymology of the model names of German trolleybuses;

– to determine the types, specific design solutions of the first MAN trolleybus generation and the prerequisites for their appearance in Chernivtsi;

– to trace the stages of operation of MAN trolleybuses in Chernivtsi, Kyiv, and Dnipropetrovsk during 1939–1951;

– to analyze the technical characteristics of the first MAN trolleybus generation, which were operated in Ukrainian cities.

Results and discussion.

Models of the rolling stock traditionally contain the name of the manufacturing plant (for example, Neoplan, Ikarus, LAZ, etc.), a specialized code (for example, MTB – for the Tushino Machine-Building Plant, AKSM – for the Belkommunmash Plant), or a numerical designation (for example, Kyiv-6, Škoda 8Tr, Henschel HS 6500). Many trolleybus models of German manufacturers had a similar designation; however, small-scale models were often not assigned numerical indexes or they were lost over time, and only the chassis index remained known. In this case, the name of the trolleybus consisted of three parts: 1) the name of the chassis manufacturer and its index, if it existed; 2) the name of the body manufacturer; 3) the name of the electrical equipment manufacturer.

This scheme is explained by the fact that, firstly, a trolleybus chassis was produced in Germany, which, in addition to the supporting frame, included a complete transmission, a suspension, axles, a braking system, a steering, a compressor with receivers and a drive motor for it; the set also, as a rule, included traction motors and a dynamotor (dynamo) (Figure 1).

Most of the trolleybus chassis was equipped with a massive fixing rack for the trailer (due to the insufficient passenger capacity of small-sized trolleybuses, many cities in Germany tested their operation with trailers), which was attached to the supporting frame in the rear overhang. The MAN and Henschel trolleybuses of the 1930–1940s had a similar chassis layout (Kenning & Schindler, 2009, p. 10; Kiebler, 2000). Secondly, such a chassis could be adapted to the body of another manufacturer, which became widespread in Germany. Trolleybus bodies were manufactured by more than 15 companies, in particular Schumann (Werdau), Bussing, Vetter (Fellbach), Kassbohrer (modern Setra), Rathgeber, etc. A similar situation has developed with electrical equipment mounted at the request of the customer. It should be noted that the trolleybus facilities in Germany used electronic equipment of such brands as Brown, Boveri & Cie, Siemens-Schuckertwerke, AEG, later – Secheron, Vossloh.

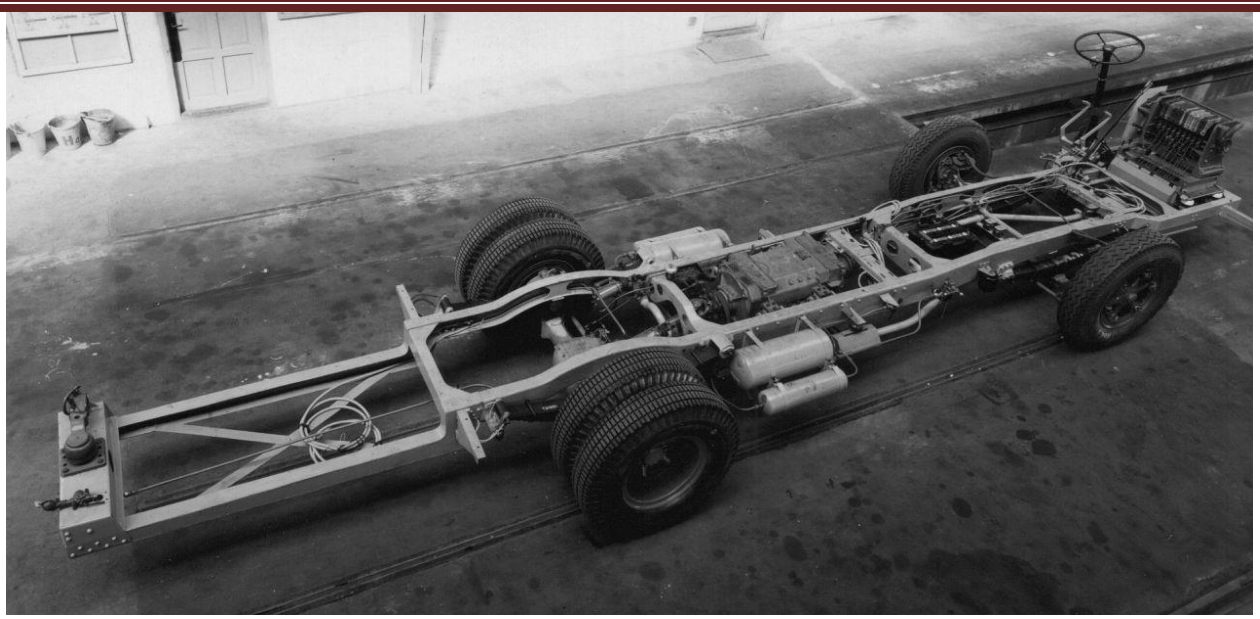

Figure 1. MAN MPE I standard trolleybus chassis, the 1940s model. The wheelbase is 4.25m, which is 1m less than in the early cars of the 1938 model. Also, early trolleybuses (Chernivtsi, Zwickau) had a rear axle single-tire wheel (in the photo – a classic double-tire wheel) (Kiebler, Ronald, 2000a).

Consequently, the name of the trolleybus consisted of three parts, which was often reflected in the technical documentation, even if there was a more accurate designation of the model (Kenning & Schindler, 2009, pp. 43–45).

As for the MAN trolleybuses, the manufacturing plant did not assign them an official numerical index, so there is no established name for the vehicles in the documented sources. Thus, such researchers as S. Tarkhov, K. Kozlov, and A. Olander (2010, pp. 156–157) operate with the word "trolleybuses", noting only manufacturers of bodies, assemblies, and electrical equipment. K. Kozlov and S. Mashkevych (2009) use the names "MAN-SSW" and "MAN-BBC". However, in view of the data contained in the Obusse in Deutschland, it can be argued that the trolleybus from Zwickau had the same chassis, called "MAN MPE I" (we are talking about its early version, since the wheelbase was one meter longer than its classic version) (Kenning & Schindler, 2009, pp. 208–209). So, in our opinion, it is advisable to call it MAN MPE I/MAN/BBC, MAN MPE I/MAN/SSW.

It is also possible to suggest that the names of trolleybuses with similar body, chassis, and electrical equipment manufacturers and without existing numerical indexes should be supplemented with the designation of the city, in which the trolleybuses were operated, such as MAN MPE I/Schumann/BBC (Zwickau). It should be noted that, according to German standards, Chernivtsi trolleybuses belong to dimension I.

History of appearance, production, and operation. The positive experience of operating the first-generation trolleybuses in the early and mid-1930s aroused

significant interest among automobile operating companies in Europe. It is worth recalling that the trolleybus motor, unlike the bus diesel one, did not pollute the atmosphere and did not need a gearbox. Moreover, according to statistics, trolleybuses had a significantly longer amortization period (approximately 12–15 years (Tarkhov, Kozlov, & Olander, 2010, p. 151)), according to other data that related to German-made trolleybuses, incl. "MAN", – 20-30 years (Lochte et al., 1991, pp. 394–399).

The MAN plant in Nuremberg, like several other German engineering companies, attempted to produce electric vehicles, producing a series of four trolleybuses in 1934–1935. Three-axle trolleybuses with a box-shaped body shape characteristic of that time were named MAN 8E2 after the chassis index and the nickname "Elbus" (Kenning & Schindler, 2009, pp. 43–45). The design solutions embodied in these vehicles, in particular the motor-in-wheel, porcelain insulating materials for electrical equipment and the water boiler heating system, were progressive, although the bow heads remained roller ones (Jurziczek, 2004). In addition, the MAN 8E2 transmission included two Siemens DG344A single-commutator motors with a capacity of 44 kW·h (Kenning & Schindler, 2009) (according to other sources, Siemens DW 602A with a capacity of 45kWh) (Jurziczek, 2004)), which were fixed on the side members of the bearing frame from the outside and transmitted the torque directly to each traction wheel (a middle pair) through differentials with a conical final drive. Thus, the trolleybus did not have a classic axle.

One of these trolleybuses was presented at the Internationalen Automobilausstellung – 1935 Exhibition (Frankfurt am Main). Such vehicles have been in service on German roads for over 20 years. So, the first attempt to produce electric vehicles for the MAN plant was successful.

At the beginning of 1937, the magazine "Verkehrstechnik" proposed to use a parameter called Normgröße (in English "normalized size"), which consisted in the need to systematize the dimensions of trolleybuses, according to 4 types of dimensions:

I – length up to 9 m (according to other sources, up to 10 m);

II – length from 9 m to 10 m;

III – length from 10 m to 11 m;

IV – length from 11 m to 12 m (at that time – three-axle vehicles) (Kenning & Schindler, 2009, pp. 10–11).

It should be added that in the 1950s, the Austrian Graf & Stift company supplemented this classification by including the V, VI, and VII types of dimensions to designate their articulated vehicles, but such designations were not widely used.

Note that these designations are rather arbitrary. They might not coincide with the real length of the trolleybus, however, for differentiation of vehicles with a length of 8.6 m and 10.1 m (the dimensions of the Henschel machine-building enterprise – I and II) were considered quite satisfactory (Kozlov & Mashkevych, 2009, p. 484). It should be borne in mind that it is difficult to determine the standardized size if the vehicle body length is, for example, 9m, as in the MAN MPE 4500 with the Schumann Werdau body. In this case, the manufacturer's designation should be followed.

The need to standardize trolleybuses was considered by the German Commercial Vehicle Manufacturers' Union (Verband deutscher Kraftverkehrgesellschaft) in Dortmund. The result of the meeting was the Order dated September 9, 1937, for the enterprises: Daimler-Benz, Kassbohrer, Schumann, DUWAG, AEG, BBC, and SSW to develop a concept. In March 1938, the Union drew up plans for the production of Type I and Type II vehicles (Kenning & Schindler, 2009, pp. 10–11). Considering the above, we can conclude that the Chernivtsi MAN vehicle belongs to type I dimensions, since its body length is 8.7 m (Kozlov & Mashkevych, 2009, p. 484).

At the beginning of 1937, due to the ineffective operation of buses, the Bukovyna Joint Regional Transport Company (BJRTC), which included the tramway facilities of Chernivtsi, began to study the experience of European countries in the use of trolleybuses. Inquiries on this issue were sent to a number of European countries. Positive foreign experience has contributed to the rapid introduction of the trolleybus service in Chernivtsi (Tarkhov, 1997b, pp. 23–24). The auction for the purchase of trolleybuses was held on April 22, 1937. BJRTC has decided to buy vehicles abroad. Initially, it was planned to purchase five trolleybuses, but the mayor's office has allocated 6 million lei for the purchase of only four units. It should be added that the costs of building a trolleybus facility in the city totaled 12.4 million lei (Tarkhov, 1997, p. 23; Tarhov, Kozlov, & Olander, 2010, p. 152). According to German prices, one MAN trolleybus of this model cost 38,300 Reichsmarks (Tarkhov, Kozlov, & Olander, 2010, p. 152).

It is difficult to name the foundations of BJRTC for ordering small-batch trolleybuses with electrical equipment from two different manufacturers, the operating experience of which did not go beyond Germany, Austria, and Switzerland by the end of the 1930s. Moreover, Ukrainian sources contain some inaccuracies. So, some of them provide information that trolleybuses were manufactured in Augsburg (Tarkhov, 1997, pp. 23–24; Kozlov & Mashkevych, 2009, pp. 54–58), while others indicate the Nuremberg plant (Lochte et al., 1991, pp. 394–402). According to the MAN commercial vehicle guide, the first-generation trolleybuses were manufactured only at the plant in Nuremberg (Kenning & Schindler, 2009, p. 46), which contradicts the data of Ukrainian sources.

It cannot be argued that these MAN trolleybuses (and not other MAN vehicles, which since 1938, there have been a large number) were ordered for the city of Chernivtsi (Tarkhov, Kozlov, & Olander, 2010, p. 156), as the trolleybuses mentioned above were originally intended for the Berliner Verkerhrsbetriebe transport company (BVG). They were assembled in the autumn of 1938, and one of them repeated the success of its predecessor (MAN 8E2), since the MAN trolleybus entered the exhibition for the second time. This time it was called Wagenschau Düsseldorf and took place on November 17–19, 1938. All modern models of transport were presented at the exhibition, including tramways and trolleybuses, in particular a trolleybus with electrical equipment manufactured by SSW (Kenning & Schindler, 2009, p. 46). Another model of MAN trolleybuses also aroused interest among specialists (Tarkhov,

1997, p. 24; Tarkhov, Kozlov, & Olander, 2010, p. 156; Kenning & Schindler, 2009, pp. 42–46).

The exact date of manufacture of the vehicles has not been defined, although it is known that the assembly of trolleybus bodies began in the spring of 1938, and the assembly ended in November (Tarkhov, Kozlov, & Olander, 2010, p. 153). It is doubtful that MAN, with its significant production capacity, has been assembling for half a year. It can be assumed that the use of electrical equipment from two manufacturers on a small series of four trolleybuses is a consequence of the refusal of the BVG transport company from such vehicles. It cannot be ruled out that existing electrical equipment was installed on them.

The transportation of MAN trolleybuses to Chernivtsi was carried out by Compas, the Romanian company, together with the German West & Bachmayer (with a representative office in Bucharest). The first two trolleybuses arrived on January 11, 1939, the last two – on January 14 (Tarkhov, Kozlov, & Olander, 2010, p. 153; Tarkhov, 1997, p. 24). The newspaper "Glasul Bukovinei" highlighted the arrival of electric transport in Chernivtsi and called the trolleybuses very comfortable. The first test drive took place on the night of January 12–13 and on January 21 at 22:00 all four MAN trolleybuses went for a run-in. The trolleybus service opened on February 1, 1939, three trolleybuses operated on the line, the fourth vehicle remained in reserve. Trolleybuses received inventory numbers 1–4 (Tarkhov, Kozlov, & Olander, 2010, p. 153–156; Kozlov & Mashkevych, 2009, p. 56). The MAN trolleybus with inventory number 3 is shown in Figure 2.

Figure 2. The MAN trolleybus with inventory number 3 in Chernivtsi in 1939 (Gorodskoj elektrotransport, 2002–2021b).

In June 1940, the city of Chernivtsi was joined to the Ukrainian SSR, after which the Soviet YaTB-4 began operating along with the MAN trolleybuses. Certainly,

imported trolleybuses with an all-metal welded body and more powerful traction electric motors (TEMs) were more up-to-date in nature, but in other respects (air-brake systems, sliding heads of bow), they were similar.

MAN trolleybuses operated in Chernivtsi until March 1944. The Army of the Third Reich, retreating, evacuated all rolling stock deep into Romania – the trolleybuses ended up at the Astra Brasov Automobile Plant (Kozlov & Mashkevych, 2009, pp. 56–57). According to some indications, the plant came under rocket bombardment, but the trolleybuses remained unharmed.

In the spring of 1945, after the resumption of the movement of electric transport in Kyiv, the MAN trolleybuses were taken from Brașov to Kyiv. The Kyiv trolleybus facilities experienced a shortage of rolling stock, since the weak repair base did not ensure timely restoration. In the 1940s, mostly pre-war YaTB-1 trolleybuses remained in operation, for which there were not enough spare parts and assemblies (Kozlov & Mashkevych, 2009, pp. 56–57). The operation has made adjustments: some units were replaced with Ukrainian counterparts, and plush seats in the passenger compartment were replaced with simple wooden benches (Kozlov & Mashkevych, 2009, pp. 56–57). It should be noted that German public transport manufacturers even installed plush or leatherette seats on vehicles of the 1930s. A complete set of MAN MPE (I) 4500 "luxury" trolleybuses in Salzburg in 1940 provided for soft seats. The benches were installed in the most difficult times (approximately 1942–1946) in a simplified design of KEO military-type trolleybuses to make the vehicles as cheap as possible. Most of them were made by the Henschel Machine-Building Enterprise (Kenning & Schindler, 2009).

At the end of 1947, it was decided to transfer all four MAN trolleybuses delivered to Kyiv free of charge to Dnipropetrovsk, where trolleybus service was opened in November (Kozlov, 2011). The trolleybuses were accompanied by Kyiv drivers, who briefed their Dnipropetrovsk colleagues for some time. The MAN vehicles opened the trolleybus service in Dnipropetrovsk on November 7, 1947 (Figure 3). They received inventory numbers 1–4 and operated until 1951 (Kozlov, 2011).

Technical description. The MAN MPE I/MAN/… trolleybus belongs to the models of Nuremberg trolleybuses manufactured on a special trolleybus chassis MPE I, which used unified units from different manufacturers. This design is based on a supporting frame, consisting of two side members and several crossbars, on which the body and all the necessary units are mounted. An early prototype of the MPE I trolleybus chassis was used by MAN trolleybuses in Zwickau (No. 21–22) (Kenning & Schindler, 2009, p. 208). Their main feature was single-rod current transfer through one massive two-pole rod as an experiment of the Brown, Boveri & Cie Plant (Kenning & Schindler, 2009, pp. 198–208; Společnost pro veřejnou dopravu, 2011). The wheelbase of the MAN MPE I chassis, as mentioned above, was 5.25 m (Drehscheibe Online...), while the classic chassis was 4.25 m, that is, one meter less (Kiebler, 2000; Lochte et al., 1991, pp. 394–401). It was this chassis that the MAN MPE I 4500 series, known for its work in Esslingen (Kiebler, 2000), Eberswalde, and other cities of

Germany, had. By the way, several 8.6-meter vehicles appeared even in Sofia (Bulgaria). They differed only in the body manufacturer, at the same time, the body length was 8.65–9.25 m (Drehscheibe Online...). These include the Bratislava vehicle MAN MPE I/Sodomka/Siemens, which is very similar in body layout to the trolleybus in Zwickau (with a single door for entry and exit with a width of 1.15 m) (Kenning & Schindler, 2009, pp. 208; Popis typu vozidla…, n. d.). The body frame, mounted on the frame, consisted of rectangular tubes made of nickel-plated steel. This material ensured the proper rigidity of the structure and a relatively light container – the trolleybus curb weight was only 8.5 tons (Tarkhov, 1997, pp. 23–24). The cladding consisted of solid-drawn steel sheets welded to the frame.

Figure 3. The MAN MPE I/MAN/BBC trolleybus opens trolleybus service in Dnipropetrovsk on November 7, 1947 (Kozlov, 2011).

Since 1938, the MAN plant in Nuremberg has been producing trolleybus chassis on which bodies from different manufacturers could be mounted. In Esslingen, trolleybuses on the MAN MPE I 4500 chassis were operating with bodies from three different manufacturers: Schumann Werdau GmbH, Kassbohrer Ulm (modern bus manufacturer Setra), and Vetter Fellbach (Kiebler, 2000). The resource of the body of these trolleybuses is not indicated in the sources, however, taking into account the documentation on the operation of similar models of trolleybuses, it can be argued that with proper maintenance, the vehicles are capable of operating from 20 to 27–31 years.

MAN MPE I/MAN/… trolleybuses in Chernivtsi had a body length of only 8.7 m, which makes it possible to classify them as type I (Kozlov & Mashkevych, 2009, p. 484; Kenning & Schindler, 2009, p. 11). German manufacturers of trolleybus chassis and body shown a flexible approach, as 11-meter (and longer) trolleybuses were not in high demand on routes and in cities with low passenger traffic. Moreover, small-sized trolleybuses have shown themselves to be maneuverable on narrow streets, where large-scale equipment is not able to work. The MAN trolleybuses considered in the study are as close as possible to the MAN vehicles in Eberswalde (in appearance) and Zwickau (base – 5.25 m) (Drehscheibe Online…). MAN trolleybuses related to Chernivtsi models are shown in Figures 4–6.

Figure 4. MAN MPE I/Schumann/BBC trolleybus produced in 1938 with a single-rod current collector in Zwickau (the two-pole rod was later replaced by two conventional collectors) (Gorodskoj elektrotransport, 2002–2021a).

In those days, the box-shaped body of the trolleybus became widespread due to the relative ease of manufacture. The streamlined forms of the MAN vehicles from Zwickau really looked futuristic, but the Chernivtsi trolleybuses had a strict design, very close to their successors – the single-pole trolleybuses from Eberswalde. The half windshield was framed by thin aluminum profiles, the front end was tapered to a certain extent, starting from the front overhang, and the lighting technology is traditionally represented by single rounded headlights. The route indicator of the trolleybus had a peculiarity: the signs with the directions of movement could be replaced at the final stop with a lever from the driver's cab using a tape (Tarkhov, Kozlov, & Olander, 2010, p. 157). The bumper with bottom-mounted “MAN.” logo blocked access to the

contactor panel, the air absorber of which is visible in the photographs (Figures 4–6), so it had to be removed to service the electrical equipment.

Figure 5. MAN MPE 4500 I/Sodomka/SSW trolleybus produced in 1940 with current collectors mounted on one axle in Bratislava (then Czechoslovakia) (Popis typu vozidla…, n. d.).

Figure 6. MAN MPE 4500 I/Kassbohrer/BBC trolleybus produced in 1944 with standard current collectors and camouflaged headlights in Esslingen (pictured late model on MAN MPE I chassis) (Kiebler, Ronald, 2000b).

The electrical equipment of Chernivtsi vehicles was produced by two firms – Siemens-Schuckertwerke and Brown, Boveri Cie (Tarkhov, Kozlov, & Olander, 2010, pp. 156–157). Traditionally, in the first generation of German trolleybuses (Kiebler, 2000), it was placed under the floor of the passenger compartment and mounted on a frame. The traction motor was located in the wheelbase closer to the rear axle. A two-commutator 90kWh motor was installed on trolleybuses with Siemens-Schuckertwerke electrical equipment (Kenning & Schindler, 2009, pp. 42–46) and with Brown, Boveri & Cie electrical equipment – 85kWh motor. The transmission included a cardan drive and a single-stage left-offset gearbox (differential) that transmitted torque to the rear traction wheels. Both driven and driving axles were manufactured by MAN. The sources do not contain information about the type of rear-axle drive and the gear ratio of the rear axle. It can be assumed that it was equal to 1:9.94, as in vehicles in Zwickau and Esslingen (Kiebler, 2000; Společnost pro veřejnou dopravu, 2011). It is impossible to determine the type of the main gear, since the MAN trolleybuses were equipped with different types of gears: for example, the MAN 8E2 vehicles were equipped with a conical rear-axle drive (Jurziczek, 2004), while the vehicles in Zwickau had a worm-gear (gear-screw) one (Společnost pro veřejnou dopravu, 2011), and later MKE series (1, 2, 3, 590 HEC I) had a conical one (M.A.N., 1956).

Chernivtsi vehicles had dependent spring suspension of driven and driving axles and diskless single wheels with tires measuring 12.00–20.00 (later the tire size on MAN trolleybuses became much smaller – 9.75 or 10.00–20.00) (Kenning & Schindler, 2009, p. 10; Lochte et al., 1991, pp. 397–399). MAN trolleybuses had tires of the Swiss production: GF, Trilex (Lochte et al., 1991, pp. 396–398). As for the type of braking system, since the vehicles in Zwickau had a two-circuit one, it can be assumed that there is a braking system of the same type for Chernivtsi trolleybuses.

Like other models of MAN vehicles, they were equipped with three types of brakes – electrodynamic, pneumatic, and parking. The advantage of the detail is the spare wheel, in the original version, placed on a stand, which was fixed on the rear panel. Spare wheels were provided for vehicles in Bratislava (Popis typu vozidla…, n. d.) and Zwickau (Kenning & Schindler, 2009, pp. 198–209). They are absent on trolleybuses of the MPE 4500 and MKE series. As the photos of Kyiv and Chernivtsi vehicles show, spare wheels were not transported on the rear panel.

The vehicles in Chernivtsi were equipped with standard slip collectors, in contrast to the MAN 8E2, where American-made Dickinson Electric roller heads were installed (Jurziczek, 2004). On the basis of the poles, special headlights were mounted for lighting at night, which German manufacturers had practiced before. The electrical kits, as indicated above, were mounted on a supporting frame.

MAN trolleybuses had a rheostatic-contactor control system (RCCS) of the traction motor, which was carried out in two versions. The first version from SSW was automatic. The switching of the groups of starting and brake rheostats was carried out using a group rheostatic controller (GRC), the shaft of which was driven by a service electric motor powered by a high-voltage network (Kenning & Schindler, 2009,

pp. 42–46). It should be noted that the servo motors from GRC in future generations of trolleybuses (for example, in the Soviet ZiU-5 trolleybus) were powered from a low-voltage network (12V or 24V). The clutch pins mounted on the electric motor, during the rotation of the GRC shaft, closed and opened the contacts, sequentially removing certain rheostats from the motor circuit, thereby increasing the TEM current. A drawing of the MAN MPE I/MAN/SSW trolleybus is shown in Figure 7.

This option was more expensive and less common than the manual option. The developer of the latter was the Brown, Boveri & Cie in 1930 (Electric drive…, 2008). The non-automatic RCCS was tested on two experimental trolleybuses, one of which was manufactured jointly by Daimler-Benz and the BBC and was used for 8 years on a special line in Mannheim and, from November 1938, it worked in Zwickau at No. 20. Its total service life was 29 years (Kenning & Schindler, 2009, pp. 208–209). There is no data on the second vehicle.

The non-automatic version of the RCCS by BBC provided for the actuation of the driver controller from the accelerator pedal or the brake pedal (Kiebler, 2000), which closed the contact clutch pins with the help of rods, accordingly, the contactor coil circuit was closed, and it, magnetizing, pulled the movable contact, which removed the rheostats from the traction motor circuit (Kiebler, 2000; Popis typu vozidla…, n. d.). A non-automatic RCCS was installed on most German trolleybus models; it was discontinued in the mid to late 1950s. Low-voltage electricity consumers, in particular passenger compartment lighting, sound signals, trolleybus dashboard equipment, were powered by a generator (a dynamotor) and, in case of current collectors falling from the contact network or no current in it – from one battery. Its exact characteristics have not been established, however, given the average performance of the MAN and Henschel trolleybuses, the capacity of such a battery should be approximately 0.7–1.2 kW·h and its capacity should be 150–162 A·h.

The generator was mounted on a base frame and powered by the TEM. The generator and the battery were manufactured by Bosch. The compressor, which ensured the functioning of the vehicle door opening mechanism and the operation of the braking system, was driven by a high-voltage electric motor and filled with compressed air two receivers with a capacity of 40 liters (Kiebler, 2000; Drehscheibe Online…).

The MAN MPE I/MAN/ trolleybuses had a doorway layout unusual for the first-generation German trolleybuses – in the front overhang and in the base. In 1940, their location changed, according to the principle: “front overhang – rear overhang” or “base (offset to the front axle) – rear overhang”. Certainly, there were vehicles with four-wing doors in the base, to which the MAN trolleybuses in Zwickau and Bratislava belonged (Kenning & Schindler, 2009, pp. 208–209; Popis typu vozidla…, n. d.), as well as an unusual design later model of the second half of the 1940s, the most common in Munich – Kraus-Maffei KME 130 (with the Rathgeber body, since the Kassbohrer body assumed two doors located in the wheelbase). The following models, including

one of the most common trolleybuses in Germany ÜHIIIs by Henschel & Uerdingen, had a classic three-door layout.

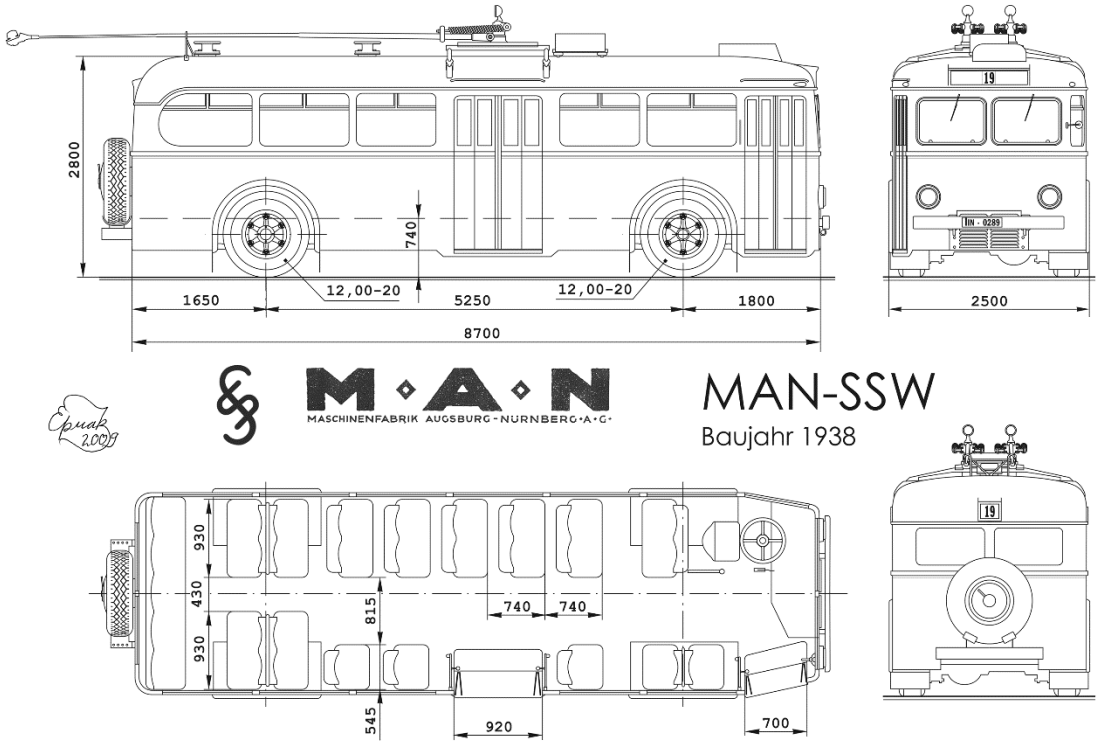

Figure 7. A drawing of the MAN MPE I/MAN/SSW trolleybus (Kozlov & Mashkevych, 2009).

In the original configuration, the MAN trolleybuses had 30 seats, the upholstery of which was made of plush (Tarkhov, Kozlov, & Olander, 2010, pp. 151–152), however, after refurbishment in Kyiv, they were replaced with simple wooden benches – eight doubles on the left side, two doubles in the rear overhang, and five single ones further. At the back was a five-seat sofa, also typical of vehicles in Zwickau. It should be noted that the layout of the trolleybus passenger compartment could differ significantly, depending on the customer's wishes. The windows provided two hinged vents for each one (for safety). The trolleybuses were not equipped with roof hatches (this type of ventilation was not widely used on German vehicles). Forced ventilation with electric fans was not provided, although a scrap from the newspaper "Glasul Bukovinei" dated January 12, 1939, given in the encyclopedic guide by S. Tarkhov, K. Kozlov, and A. Olander, convinces that "…the lighting is electric, and the ventilation is automatic…" (2010, p. 157). In our opinion, this is a technical mistake, since it is known that German manufacturers, including MAN, were already experimenting with forced ventilation. It could be tested at the presentation of the MAN MPE I 4500 with an improved configuration (with Schumann body and BBC electrical equipment) in Salzburg during the opening of the trolleybus service in 1940. Heating

of the passenger compartment in the cold season was carried out with the electric furnaces (Tarkhov, Kozlov, & Olander, 2010, p. 157). German-made vehicles were equipped with them by default, with the exception of the period for which manufacturers had to save on picking (approximately 1942–1946). In addition to Germany, simplified trolleybuses also operated in Gdynia (both German and local assembly – on the Henschel chassis with the body by the Gdansk Carriage Works).

Table 1 shows the technical characteristics of the MAN MPE I/MAN/SSW and MAN MPE I/MAN/BBC trolleybuses.

Table 1. Technical characteristics of MAN trolleybuses

Parameter	Value	Source or clarification
General information		
Chassis manufacturer	MAN (Nuremberg)	Tarkhov, Kozlov, & Olander, 2010, p. 157
Body manufacturer	MAN (Nuremberg)	Tarkhov, Kozlov, & Olander, 2010, p. 157
Electrical equipment manufacturer	Brown & Boveri, Cie, Siemens-Schuckertwerke	Tarkhov, Kozlov, & Olander, 2010, p. 157; Kenning & Schindler, 2009, pp. 42–43; Kozlov, 2011
Body		
Body	with frame base, welded, all-metal; frame sheathing and tubes are made of nickel-plated steel	Kozlov & Mashkevych, 2009, p. 56; Kiebler, 2000; Drehscheibe Online…
Chassis	MAN MPE I	documentation Kenning & Schindler, 2009; Büllov, 1997
Overall dimensions		
Body length, mm	8700	Kozlov & Mashkevych, 2009, p. 484; Kenning & Schindler, 2009, pp. 42–43
Width, mm	2500	Kozlov & Mashkevych, 2009, p. 484
Body height, mm	2800	Kozlov & Mashkevych, 2009, p. 484

Wheelbase, mm	5250	Kozlov & Mashkevych, 2009, p. 484
Front overhang, mm	1800	Kozlov & Mashkevych, 2009, p. 484
Rear overhang, mm	1650	Kozlov & Mashkevych, 2009, p. 484
Interior floor height above surface level, mm	740	Kozlov & Mashkevych, 2009, p. 484
Motor and electrical equipment		
Type	Siemens DV602a, four-pole, two-commutator, series-wound BBC GLM 1273 DK, four-pole, two-commutator, series-wound	Kenning & Schindler, 2009, pp. 42–46; Společnost pro veřejnou dopravu, 2011
Power, kWh	90 85	Kenning & Schindler, 2009, pp. 42–46; Společnost pro veřejnou dopravu, 2011
Nominal armature speed, rpm	1500	Kenning & Schindler, 2009, pp. 42–47
Voltage of high-voltage electrical equipment, V	550	documentation
Voltage of low-voltage electrical equipment, V	12	documentation
TEM management	rheostatic-contactor automatic (SSW) non-automatic (BBC)	Kozlov & Mashkevych, 2009, p. 484
TEM placement	wheelbase (moderately offset to the rear axle)	documentation
Low voltage electrical equipment manufacturer	Bosch	documentation

Transmission and braking system		
Gear system	single-stage, with differential offset on the port side	Tarkhov, Kozlov, & Olander, 2010, p. 157
Drive axle	MAN (rear axle)	Kiebler, 2000
Rear-axle ratio	1:9.94	Kiebler, 2000
Rear-axle drive	tapered or worm-gear (it is not precisely established by sources and documentation)	Drehscheibe Online…; Společnost pro veřejnou dopravu, 2011; M.A.N., 1956; Kenning & Schindler, 2009, pp. 42–46
Braking system	pneumatic double-circuit	Kenning & Schindler, 2009, p. 208–209
Dynamo	Bosch	documentation
Compressor unit	Bosch	documentation
Passenger compartment		
Number of doors for passengers	2	Kenning & Schindler, 2009, pp. 42–47; Kozlov & Mashkevych, 2009, p. 484
Doors, type	four-wing, platen-type, with pneumatic opening mechanism	Kozlov & Mashkevych, 2009, p. 484
Front door width, mm	700	Kozlov & Mashkevych, 2009, p. 484
Second door width, mm	920	Kozlov & Mashkevych, 2009, p. 484
Single seat width, mm	545	Kozlov & Mashkevych, 2009, p. 484
Double seat width, mm	930	Kozlov & Mashkevych, 2009, p. 484
Seat clearance, mm	740	Kozlov & Mashkevych, 2009, p. 484
Aisle width between rows, mm	815	Kozlov & Mashkevych, 2009, p. 484

	430 (rear overhang)	
Number of seats in the passenger compartment, pcs.	30	Kozlov & Mashkevych, 2009, p. 56
Total capacity, pass.	50	Kozlov & Mashkevych, 2009, p. 56
Additional information		
Tire size	12.00–20.00	Kozlov & Mashkevych, 2009, p. 484
Putting on a tire	single-tire (front axle) single-tire (rear axle)	Kozlov & Mashkevych, 2009, p. 56
Tire manufacturer	GF, Trilex (Switzerland)	Lochte et al., 1991, pp. 395–398
Maximum speed, km/h	58	Kenning & Schindler, 2009, pp. 42–46

Conclusions.

Urgent environmental problems of our time are increasingly forcing the governments of States, including Ukraine, to pay attention to the expansion of the infrastructure of e-transport. Its most developed component in Ukraine is trackless e-transport, the first trolleybus line of which celebrated its 85th anniversary in 2020. Despite the interest of researchers in the history of e-transport, its technical characteristics, and role in the socioeconomic development of local communities, many different aspects remain without their attention. One of the little-known pages in the history of e-transport in Ukraine is the operation of MAN trolleybuses in Chernivtsi, Kyiv, and Dnipropetrovsk during 1939–1951.

MAN trolleybuses have appeared on the roads of Ukraine in the mid-2010s after more than sixty-year hiatus. The Ukrainian and German practice of naming trolleybus models has common features: the name consists of the abbreviation of the manufacturing plant, to which a digital or alphabetic index is attached.

In the early 1930s, European motor transport concerns are interested in the production of trolleybuses, which had a number of advantages over buses: environmental friendliness, simpler transmission, and longer service life. It was the unsatisfactory condition of buses in the urban transport sector that forced the municipal authorities of Chernivtsi to introduce a trolleybus network. The opening of the trolleybus service on February 1, 1939, was an outstanding event in the life of Chernivtsi, which became the second Ukrainian city after Kyiv, where this type of transport began to be used. Operation of MAN trolleybuses in Chernivtsi has continued

both after joining Bukovyna to the Ukrainian SSR and during the Second World War until June 1944. In the postwar period, Chernivtsi MAN trolleybuses worked on the lines of Kyiv and in 1947–1951 – in Dnipropetrovsk.

In appearance, equipment, and technical characteristics, the MAN trolleybuses, which entered the line in Chernivtsi in 1939, can be attributed to the first generation of German trolleybuses. They did not differ much from similar models operating at that time in Germany or Poland, but they had more powerful electric motors and comfortable interiors than Soviet trolleybuses.

The existing source base did not allow to determine the exact dates of the vehicle production and the reasons for the purchase of this particular model of trolleybuses by the Chernivtsi municipality from the MAN Concern. Some of their technical characteristics also remain unclear. The attraction of new sources can reveal the above aspects and describe in more detail the period of operation of Chernivtsi trolleybuses in Kyiv and Dnipropetrovsk before their decommissioning in 1951. The characteristics of the MAN trolleybuses given in the work can be used both in historical works and in studies of a technical nature. In the future, the methodology and the structure of the research proposed by the authors can be used in the studying the history of e-transport at the local and regional levels.

Funding.
This research received no external funding.

Conflicts of interest.
The authors declare no conflict of interest.

References

Bramskyi, K. A. (2011). Pershomu v Ukraini kyivskomu troleibusu 75 rokiv [The first Kyiv trolleybus in Ukraine is 75 years old now]. *Pytannia istorii nauky i tekhniky – Problems of the history of science and technology, 1,* 64−69 [in Ukrainian].

Büllov, Hartmut. (1997). Die Obus-Stadt Eberswalde [The trolleybuses of Eberswalde]. Retrieved from www.obus-ew.de [in German].

Drehscheibe Online Foren [Wheel online forums]. Retrieved from http://www.drehscheibe-online.de/foren/read.php?17,3850785 [in German].

Electric drive and wheel hub-motors: First buses back in 1899. (May 1, 2008). *Daimler Media: Global Media Site.* Retrieved from http://media.daimler.com/marsMediaSite/en/instance/ko/Electric-drive-and-wheel-hub-motors-First-buses-back-in-1899.xhtml?oid=9361400

Gorodskoj elektrotransport [Urban electric transport] (2002–2021a). Retrieved from https://transphoto.org/photo/977152/?lang=cs [in Russian].

Gorodskoj elektrotransport [Urban electric transport] (2002–2021b). Retrieved from https://transphoto.org/photo/433645/?gid=775 [in Russian].

Hutyria, S. S., Bordeniuk, D. M., & Chanchyn, A. M. (2011). Tekhnichna evoliutsiia svitovoho i vitchyznianoho troleibusobuduvannia [Technical evolution of world and domestic trolleybus construction]. *Pratsi Odeskoho politekhnichnoho universytetu – Proceedings of Odessa Polytechnic University, 1*, 42−48 [in Ukrainian].

Jurziczek. (September, 2004). Obus Berlin. 1934 – SSW/MAN [Berlin trolleybus. 1934 – SSW / MAN]. *Berliner Verkehrsseiten: Das Online Magazin zur Berliner Verkehrsgeschichte – Berliner Verkehrsseiten: The online magazine on Berlin's traffic history*. Retrieved from http://www.berliner-verkehrsseiten.de/obus/Ocars/Obus_1101/ obus _1101.html [in German].

Kabmin planuie perevesty mista na hromadskyi elektrotransport [The Cabinet of Ministers plans to transfer cities to public electric transport]. (November 19, 2020). *Ukraina komunalna – Municipal Ukraine*. Retrieved from http://jkg-portal.com.ua/ua/publication/one/kabmn-planuje-perejvest-msta-na-gromadskij-jelektrotransport-61576 [in Ukrainian].

Kenning, L., & Schindler, M. (2009). *Obusse in Deutschland [Trolleybuses in Germany]*. Band 1. Nordhorn: Kenning Verlag [in German].

Kiebler, Ronald (Januar, 2000 a). MAN MPE 4500 Obusse Nr. 51–55 [MAN MPE 4500 Trolleybuses No. 51–55]. *Der Obus- und Duo-Bus Betrieb in Esslingen am Neckar – The trolleybus and duo bus operation in Esslingen.* Retrieved from http://www.obus-es.de/th_51-55.htm [in German].

Kiebler, Ronald (Januar, 2000 b). MAN MPE 4500 Obusse Nr. 51–55 [MAN MPE 4500 Trolleybuses No. 51–55]. *Der Obus- und Duo-Bus Betrieb in Esslingen am Neckar – The trolleybus and duo bus operation in Esslingen.* Retrieved from http://www.obus-es.de/th_56-60.htm [in German].

Kozlov, K. P., & Mashkevych, S. V. (2009). Kyivskyi troleibus / Kiev Trolleybus. Kyiv: KYI [in Ukrainian/English]

Kozlov, K. (2011). M.A.N. *Urbantransport.kiev.ua*. Retrieved from http://urbantransport.kiev.ua/ua_212.html [in Ukrainian].

Kryvoviaziuk, I. V., & Kraichuk, S. O. (2016). Analiz ukrainskoho rynku avtobusobuduvannia ta troleibusobuduvannia [Analysis of the Ukrainian market of bus and trolleybus construction]. *Ekonomichnyi forum – Economic forum, 2,* 51−61 [in Ukrainian].

Lochte, W., Diener, M., Hausen, H., Roegner, H., Bosl, K., Droscha, H. … Seper, H. (1991*). Leistung und Weg: Zur Geschichte des MAN Nutzfahrzeugbaus [Performance and path: the history of MAN commercial vehicle construction]*. Berlin: Springer; Softcover reprint of the original 1st ed [in German].

M.A.N. (Maschinenfabrik Augsburg-Nurnberg): Typ 590 HEC I (MKE), Gruppe 16. (1956). Munchen: MAN (Werk Munchen) [in German].

Polinkevych, O. M. (2019). Diahnostyka rynku miskoho elektrotransportu Ukrainy [Diagnosis of the urban electric transport market of Ukraine]. *Ekonomichnyi forum – Economic forum, 1,* 120−124 [in Ukrainian].

Popis typu vozidla, MAN-MPE-Sodomka-Siemens *[Vehicle type description, MAN-MPE-Sodomka-Siemens]*. (n. d.). *Imhd.sk.* Retrieved from https://imhd.sk/ba/popis-typu-vozidla/26/MAN-MPE-Sodomka-Siemens [in Czech].

Tarkhov, S. (1997a). *100 Jahre elektrischer Nahverkehr in der ehemaligen Landeshauptstadt Tschernowitz [100 years of local electric transport in the former state capital Chernivtsi]*. Oslo: Baneforlaget [in German].

Tarkhov, S. A. (1994). *Istoriia lvivskoho tramvaia [The history of the Lviv tram]*. Lviv: Feniks Ltd [in Ukrainian].

Tarkhov, S. A. (1997b). *Istoriia miskelektrotransportu Chernivtsiv [The history of urban electric transport of Chernivtsi]*. Chernivtsi: "Prut" [in Ukrainian].

Tarkhov, S. A. (1998). *Pervyj v Krymu: Istoriya tramvaya i trolleybusa v Sevastopole [The first in Crimea: The history of the tram and trolleybus in Sevastopol]*. Sevastopol [in Russian].

Tarkhov, S., Kozlov, K., & Olander, A. (2010). *Elektrotransport Ukrainy: Entsyklopedychnyi putivnyk [Electric Transport of Ukraine: Encyclopedic Guide]*. Kyiv [in Ukrainian].

Společnost pro veřejnou dopravu [Public Transport Company] (2011, April 07). *Trolejbusy ve Zwickau [Trolleybuses in Zwickau]* Retrieved from http://spvd.cz/index.php/nemecko/zwickau [in Czech].

Анатолій Литвиненко
Балтійська міжнародна академія, Латвія
Львівський національний університет імені Івана Франка, Україна
Університет Роберта Гордона, Великобританія

Віктор Саранча
Кременчуцький національний університет імені Михайла Остроградського, Україна

Вікторія Шабуніна
Кременчуцький національний університет імені Михайла Остроградського, Україна

Тролейбуси "MAN" в Україні (1939-1951): історія, технічні характеристики, особливості експлуатації

Анотація. *Зростання автомобільного парку й автобусних перевезень у містах України підвищує рівень забрудненості навколишнього середовища. В умовах екологічної кризи електротранспорт стає об'єктом наукових досліджень, предметом дискусій у середовищі політиків і громадських діячів. У програмі розвитку муніципального господарства України пріоритети надано*

розбудові інфраструктури екологічного транспорту: тролейбусів, електробусів, електромобілів. Підвищена увага до електротранспорту з боку наукового співтовариства, політикуму та громадськості актуалізує дослідження його історії, розвитку, особливостей експлуатації тощо. Проведений авторами історіографічний аналіз дає підстави говорити про недостатнє висвітлення українськими дослідниками низки аспектів і періодів в історії електротранспорту. Незначна кількість спеціальних робіт з історії експлуатації тролейбусів іноземного виробництва в українських містах у першій половині ХХ ст. та аналізу їх технічних характеристик зумовлюють актуальність і наукову новизну цього дослідження. При написанні роботи були використані українські й зарубіжні науково-довідкові видання, монографії, статті, здебільшого із закордонних електронних ресурсів. Авторами були застосовані як загальнонаукові (аналіз, синтез, дедукція, індукція), так і власне історичні методи дослідження, зокрема проблемно-хронологічний, порівняльно-історичний, ретроспективний методи тощо. Метою дослідження є висвітлення маловідомих фактів з історії виробництва та експлуатації в українських містах тролейбусів "MAN", а також уведення до наукового обігу їх технічних характеристик. З'ясовано етимологію назв моделей німецьких тролейбусів, яка зазвичай складалася з назв заводів-виробників шасі, кузову й електрообладнання. Визначено типи, специфічні конструктивні рішення тролейбусів "MAN" першого покоління та передумови їх появи в Чернівцях. Особлива увага зосереджена на тролейбусах, які були в експлуатації в Німеччині та інших західноєвропейських країнах із першої половини 1930-х рр. і до початку 1950-х рр. У середині 1930-х рр. випуск тролейбусів розпочав завод "MAN" у Нюрнберзі, його моделі мали найсучасніші на той час конструктивні рішення, характерний дизайн і новітню систему опалення. Залежно від довжини німецькі виробники поділяли моделі тролейбусів на чотири типи. Внаслідок проблем із експлуатацією автобусного парку в Чернівцях міська влада прийняла рішення щодо побудови в місті тролейбусної лінії; було закуплено чотири тролейбуси виробництва заводу "MAN". У статті простежено етапи експлуатації тролейбусів "MAN" у Чернівцях, де вони працювали протягом 1939–1944 рр., а після закінчення Другої світової війни були переведені до Києва. Після дворічної експлуатації в столиці тролейбуси протягом 1947−1951 рр. виходили на маршрути в Дніпропетровську. Наведено й проаналізовано технічні характеристики тролейбусів "MAN" першого покоління, які експлуатувалися в українських містах. Визначено, що за всіма основними показниками й експлуатаційними параметрами вони були максимально наближені до аналогічних моделей німецьких тролейбусів. Запропонована методологія та структура дослідження в подальшому може бути використана для написання статей з історії науки й техніки, зокрема електротранспорту.

Ключові слова: *електротранспорт; тролейбус; експлуатація; машина; Чернівці; Німеччина*

Анатолий Литвиненко
Балтийская международная академия, Латвия
Львовский национальный университет имени Ивана Франко, Украина
Университет Роберта Гордона, Великобритания

Виктор Саранча
Кременчугский национальный университет имени Михаила Остроградского, Украина

Виктория Шабунина
Кременчугский национальный университет имени Михаила Остроградского, Украина

Троллейбусы "MAN" в Украине (1939-1951): история, технические характеристики, особенности эксплуатации

Аннотация. *Рост автомобильного парка и автобусных перевозок в городах Украины повышает уровень загрязненности окружающей среды. В условиях экологического кризиса электротранспорт становится объектом научных исследований, предметом дискуссий в среде политиков и общественных деятелей. В программе развития муниципального хозяйства Украины приоритетным является совершенствование инфраструктуры экологического транспорта: троллейбусов, электробусов, электромобилей. Повышенное внимание к электротранспорту со стороны научного сообщества, политических деятелей и общественности актуализирует исследования его истории, развития, особенностей эксплуатации и т.п. Проведенный авторами историографический анализ дает основания говорить о недостаточном освещении украинскими исследователями ряда аспектов и периодов в истории электротранспорта. Незначительное количество специальных работ, посвященных истории эксплуатации троллейбусов иностранного производства в украинских городах в первой половине XX в. и анализу их технических характеристик, обуславливают актуальность и научную новизну данного исследования. При написании работы были использованы украинские и зарубежные научно-справочные издания, монографии, статьи, в основном из зарубежных электронных ресурсов. Авторами были применены как общенаучные (анализ, синтез, дедукция, индукция), так и собственно исторические методы исследования, в частности проблемно-хронологический, сравнительно-исторический, ретроспективный методы и др. Целью исследования является освещение малоизвестных фактов, касающихся истории производства и эксплуатации в украинских городах троллейбусов "MAN", а также введение в научный оборот их технических характеристик.*

Установлено этимологию названий моделей немецких троллейбусов. Название обычно состояло из названий заводов-производителей шасси, кузова и электрооборудования. Определены типы, специфические конструктивные решения троллейбусов "MAN" первого поколения и предпосылки их появления в Черновцах. Особое внимание сосредоточено на троллейбусах, которые были в эксплуатации в Германии и других западноевропейских странах с первой половины 1930-х гг. до начала 1950-х гг. В середине 1930-х гг. выпуск троллейбусов начал завод "MAN" в Нюрнберге, его модели имели самые современные на то время конструктивные решения, характерный дизайн и новую систему отопления. В зависимости от длины немецкие производители разделяли модели троллейбусов на четыре типа. Вследствие проблем с эксплуатацией автобусного парка в Черновцах, городские власти приняли решение о строительстве в городе троллейбусной линии; было закуплено четыре троллейбуса производства завода "MAN". В статье прослеживаются этапы эксплуатации троллейбусов "MAN" в Черновцах, где они работали в течение 1939-1944 гг., а после окончания Второй мировой войны были переведены в Киев. После двухлетней эксплуатации в столице троллейбусы в течение 1947-1951 гг. выходили на маршруты в Днепропетровске. Приведены и проанализированы технические характеристики троллейбусов "MAN" первого поколения, которые эксплуатировались в украинских городах. Определено, что по всем основным показателям и эксплуатационным параметрам они были максимально приближены к аналогичным моделям немецких троллейбусов. Предложенная методология и структура исследования в дальнейшем может быть использована для написания статей по истории науки и техники, в частности электротранспорта.

Ключевые слова: *электротранспорт; троллейбус; эксплуатация; машина; Черновцы; Германия*

Received 18.06.2021
Received in revised form 01.11.2021
Accepted 05.11.2021