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"Beautiful Helen" locomotive and more

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Summary

Poland's regaining of independence in 1918 was a powerful stimulus for many areas of social and economic life in the Polish state that was being created from scratch. One of such sectors, vital to the development of the economy and social life, was transport and the steam locomotive industry. At the time, the steam locomotive was a modern means of transport enabling people and goods to be moved over closer and further distances, quickly, efficiently and comfortably. This article presents the history of the development of the Polish school of locomotive design and construction after 1918 and, in this context, the development of research on steam locomotives constructed and built in newly established factories, and in particular the history of the design and construction of the Pt 31 steam locomotive. Following 1918, engineers, prominent steam locomotive constructors, began to return to Poland from Russia and began to perform "basic work", establishing Locomotive Construction Departments at Polish technical universities and also participating in the organisation of the production and construction of new locomotives. Examples of such figures include: Antoni Xiężopolski, Wacław Łopuszyński, Albert Czeczott or Adolf Langrod. The dynamically developing technical higher education in Poland after 2019, and in particular the mechanical faculties of the Lviv or Warsaw technical universities, resulted in the development of design offices in the emerging rail vehicle production plants such as Fablok, H. Cegielski, Warszawska Spółka Akcyjna Budowy Parowozów or PZInż. in Ursus, as well as the establishment of organisational structures in the then Ministry of Transport (Ministerstwo Komunikacji) dealing with rail transport and in particular rail vehicles. Examples include: Department of Locomotive Construction (Katedra Budowy Lokomotyw) at the Warsaw University of Technology or the Experimental Division (Referat Doświadczalny) at the Department of Mechanical Engineering of the Ministry of Transport. One of the graduates of the Faculty of Mechanical Engineering at the Warsaw University of Technology in 1928 was inż. Kazimierz Zembrzuski, who, in 1930, at the age of 25, began working in the construction bureau of the First Locomotive Factory in Poland in Chrzanów. After several years of work he designed, and then as head of the design team, supervised the construction of two prototypes of the Pm36 steam locomotive. One of these, at the International Exposition of Art and Technology in Modern Life in Paris, was exhibited in 1937. The article describes the course of development of the rolling stock construction and building industry at the beginning of the 20th century and the activities associated with the history of the Pm36 steam locomotive.

Keywords: Pm36 steam locomotive, K. Zembrzuski, Fablok

1. Introduction

One of the conference rooms of the Railway Transport Office is the "Beautiful Helen" room. One of the Rail Transport Authority's meeting rooms is the 'Beautiful Helena' room. For those not involved in rail transport, and I suspect for many of those involved as well, the name may evoke various associations not always related to railways. That is why the authors decided to bring the history of the creation of the 'Beautiful Helena' and the people associated with this name closer to the supporters of security culture and also, on occasion, to others interested. In the distant past, it was rare for a structure, building or vehicle, especially a railway, in addition to the type symbol, to have been given, by the media of the time, a name derived from Greek mythology, which described the story and fate of the king and queen of Sparta, the most beautiful woman of her time.

"Beautiful Helen" was the nickname given to a Pm36 type steam locomotive constructed and built in Chrzanów, at the Fablok locomotive factory in the inter-war period, shortly before the outbreak of the Second World War [3, 8]. The story presented in this article is an example of the rapidly developing ma-

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chine building industry in Poland in the 19th and 20th centuries, particularly the steam locomotive industry, and an example of the engineering craftsmanship represented by young graduates of the then Faculty of Mechanical Engineering at the Warsaw University of Technology. One of them was Kazimierz Zembrzuski, who, only five years after graduation, completely and independently designed the Pt 31 steam locomotive, and a year later, as head of the design office (in 1936), the Pm36 steam locomotive [5].

This story is also related to the history of steam locomotive research in Poland following regaining independence in 1918. The initiator of the idea of research and its organisation within the then structures of the Ministry of Transport was the railway engineer Albert Czeczott [1, 6], a graduate of the Institute of Railway Engineers in St Petersburg. A railway engineer since 1927, A. Czeczott was a lecturer at the Warsaw University of Technology, as a steam locomotive designer and pioneer of locomotive traction system research.

The railway system in Poland was formed over decades starting from the partitions, and its dynamic development began from the moment Poland regained independence. The railway system is infrastructure and rolling stock, as well as people, research and industry providing new construction solutions in the area of railway infrastructure and rolling stock. The infrastructure solutions introduced from 1918 onwards were based on solutions that were already in place in Germany, France or England. In the early days of after regaining independence, in the area of railway vehicles, the Polish railways used and operated vehicles constructed and manufactured in the above countries. The reason for this was obvious: there was a lack of Polish universities and Polish production plants to provide new design solutions and new vehicle prototypes. However, as early as the beginning of 1918, the process of transforming the existing universities in the territories of the various partitions into universities subordinate to the newly formed technical higher education system began in Poland. The dynamic development of the machine-building industry, particularly locomotive construction, also began. This topic is developed further in the next chapter.

2. The Development of the Polish School of Locomotive Construction and Engineering

The complex history of Poland, including its territorial and administrative divisions, especially after 1795 (the third partition of Poland), is directly linked to the development of the railway on Polish territory in the 19th century and later. Therefore, the background information provided at the beginning of this article on the development of the railways in the territories of the individual partitions will provide a context for the construction and building of rolling stock in Poland after 1918.

A short history of the development of railways in Poland

The beginning of the development of the international railway industry was marked by the invention of the steam engine and its use, as is generally accepted in history, in the first Rocket steam locomotive designed in 1825 by George and Robert Stephenson. The date mentioned can be considered symbolic, as the development of road steam vehicles, later called locomotives, began in the second half of the 18th century and the first road steam vehicle was constructed by Nicolas Cugnot in 1769. In contrast, the first locomotive, which was subjected to a test run in February 1804, was constructed by Richard Trevithick for the Penydarren ironworks in Wales.

The development of the design and construction of steam vehicles took place in parallel with the development of the railway network. The leading country in this respect was England, but the states of the European continent, above all Germany, were equally rapid in developing their railway networks. In 1845, England and Ireland had 4,082 km of railway lines, Germany 2,043 km, Austria-Hungary 1,058 km, France 870 km, Belgium 577 km, the Netherlands 156 km, Russia 144 km, Italy 128, and Switzerland only 4 km. In the territories of partitioned Poland, the situation in this respect reflected the development of the railway network in the countries of the occupants, as succinctly shown in the article.

Russian Partition

The Kingdom of Poland (Russian Partition) was an interesting case in terms of railway development. The Vistula River separated two gauge systems: standard gauge (1,435 mm, so-called English) and broad gauge (1,524 mm), but the transport policy pursued by the Russian empire in this area meant that broad gauge rail was the dominant system. An exception was the Warsaw-Vienna railway, the design of which, created by Count Tomasz Łubieński, was included in the "First general project for the construction of an iron road between the city of Warsaw and the borders of the Kingdom", and was published in 1835 [2]. The assumption of an English gauge (1435 mm), adopted in the plan for the development of the railway network for the part of the Kingdom located on the left bank of the Vistula, was possible because in Russia itself at that time the issue of adopting a uniform solution for the entire empire had not yet been resolved. Construction of the Warsaw-

Vienna railway began in 1838 (and not without difficulties), and on 14 June 1845, the first 29-kilometre section linking Warsaw - Pruszków – Grodzisk stations was put into service. Construction of the railway progressed rapidly and by the spring of 1848, the total length of the Warsaw-Vienna railway was 328 kilometres and, thanks to the immediate connections from the border of the Kingdom to Austria and to Prussia, it was possible to travel from Warsaw to Vienna in 27 hours and to Berlin in 36 hours. The route was single-track. In 1850 the Warsaw-Vienna railway operated 45 locomotives, 100 passenger carriages and 318 freight carriages. The permissible speed of a passenger train was 50 km/h, a mixed train 40 km/h and a freight train 30 km/h. The opening of the Viennese railway gave rise to the construction of a network of standard-gauge railway connections within the Kingdom of Poland, with the main line known as the "wiedenka" (Viennese). Among other things, the following railway routes were established: Warsaw-Bydgoszcz railroad (136.7 km) or the Łódź-Koluszki railway (26 km). With some time delay, the broad-gauge railway network also began to develop in the Kingdom of Poland, especially in its right-bank part. The earliest was the Saint Petersburg-Warsaw railway, construction of which began in 1851 and was completed in 1861. The constructed main line, including its branches, was 1,116 km long – the terminal station in Warsaw was Petersburg Train Station, destroyed during the First World War. In 1880 a second track was added and then successive investments were made in lines of secondary importance, which connected the arterial line with the towns of the Białystok and Podlasie regions. Such lines as Małkinia – Siedlce (66 km, completed in 1887), Małkinia – Ostrołęka (54.1 km, 1893), Ostrołęka – Łapy (88.2 km, 1893), Orany – Suwałki (142 km, 1899), Tłuszcz – Ostrołęka (74.2 km, 1897) should be mentioned.

In addition to the development of railway lines based on the Warsaw-Petersburg railway arterial line, lines of strategic importance to the Russian Empire, which were also of economic significance for the development of the area, were built in the eastern part of the Kingdom. These lines also crossed into the left bank of the Kingdom. It is possible to mention such investments as: Warsaw-Terespol railway (211 km, 1867), Brzesko-Grajewo railway (209 km, 1873), Vistula railway (522 km, 1877), Ivangorod-Dąbrowa railway (462 km, 1885, the first broad-gauge railway, which passed to the left bank of the Vistula and ended in Dąbrowa Górnicza), the Warsaw-Kalisz railway (267.7 km, 1902, a broad-gauge road of strategic importance linking Warsaw with Prussia), the Herby-Kielce railway (134 km, 1911).

One should also mention the development of the broad-gauge railway network in the areas bordering the Kingdom, which before 1772 belonged to the Polish-Lithuanian Commonwealth and were called Kresy (Volhynia, Podolia). It is important to note such lines as, among others, the Libau-Romny railway (1,434 km, 1874, a line connecting the western part of Ukraine with the ports of the Baltic Sea), the Polesia railway, the South-Western railway (Zhytomyrshchyna and Podolia, construction years 1865–1896, 1,280 km), the Kovel-Volodymyr-Volynskyi, 1,906, 53 km).

Austrian Partition

The development of railways in Galicia, as in the other partitions, was dependent on the rate of development of railways in Austria. Naturally, the primary interest involved the development of the Austro-Hungarian railway, rather than connections such as those between Lviv and Drohobych or Oświęcim and Żywiec. Nevertheless, the first train appeared in Galicia in 1847, when the Mysłowice – Kraków section via Szczakowa and Trzebinia (65.7 km) was put into service. The line was built by a Prussian investor, connecting the magnificent station in Kraków with the Prussian Upper Silesian Railway in Mysłowice. In 1850, the East Imperial-Royal State Railways was established to expand the railway network of Galicia and Lodomeria. The activities carried out led to the construction of the Trzebinia-Oświęcim line (25.2 km, 1856), the Dziedzice-Oświęcim line or the Kraków-Dębica line (110.6 km). In the following years, the development of railway lines in Galicia was carried out by private companies such as the Emperor Ferdinand Northern Railway or the Galician Railway of Archduke Charles Louis. The activities of the Emperor Ferdinand Northern Railway resulted in the construction of lines such as Bielsko-żywiec, Bielsko-Bonarka, Frydek-Mistek-Bielsko, Bielsko-Kalwaria Zebrzydowska. In 1902, the total length of the lines was 1,309 km. The second of the private companies, the Galician Railway of Archduke Charles Louis, whose founder was a group of Polish aristocrats, was involved in the expansion of the railway network east of Kraków. Its activities resulted in the opening of lines such as Dębica-Rzeszów (46.9 km, 1858), Rzeszów-Przeworsk (36.7 km, 1859), Przeworsk-Przemyśl (50 km, 1860), Przemyśl-Lviv (97.6 km, 1861). At the end of 1861, the length of railway lines managed by this company was 465 km. The next stage in the activities of this company was investments in the areas to the east and south of Lviv. The company's activities brought the development of a total length of 848 km of railway lines in the 1880s. The company's activities resulted in a total length of 848 km of railway lines in the 1880s. In addition to private companies, in the 1870s and 1880s the Austrian authorities became actively involved in the construction of railway lines within Galicia. Examples include the construction of the Tarnów-Leluchów State Railway, opened in 1876, connecting Galicia with Hungary, or the Galician Transversal Railway, completed in

1884, which passed through the northern foothills of the Carpathian Mountains, connecting Żywiec, Sucha Beskidzka, Chabówka, Nowy Sącz and on to Stanyslaviv all the way to Husiatyn (the Russian border). By the end of 1885, the total length of the transversal line had reached 555.3 km. These and similar investments by the Austrian authorities enabled the economic development of the Subcarpathian areas south and east of Rzeszów. Administratively, the state railways in Galicia were initially divided between the directorates in Kraków and Lviv. In 1983, a directorate in Stanyslaviv was also established.

Prussian Partition

In the 19th century, the Prussian Partition territory was covered by the German railway network. On a European scale, the German railways were in every respect among the leaders in the area. Thus, the development of the railways in the Prussian Partition should be assessed from the perspective of the development of the German railways, as the railway policy pursued in Germany during this period was guided by the interests of the German economy, not the territories. Initially, rail investments were financed by private capital. As a result, the following were developed: The Upper Silesian Railway (1846, 196.3 km) connecting Wrocław with the border station Mysłowice and later Wrocław with Poznań and Głogów.

In 1846, construction began on the crucial Prussian Eastern Railway (Ostbahn) connecting the two Prussian capitals of Berlin and Königsberg. Initially it was a private investment, but as the years passed, the German state took over the management of the project and by 1880 the total length of the state-owned railway under the banner of the Prussian Eastern Railway was 4,833 km. Among the numerous private investments of this period are: Wrocław-Świebodzin railway, Berlin-Wrocław railway, Berlin-Wrocław secondary railway, Berlin-Szczecin railway, Opole-Tarnogóra railway, Farther Pomerania railway, Poznań-Bydgoszcz-Toruń railway and others. It is difficult to mention all of them, especially the smaller ones, which were established with the intention of developing local connections. The end of all the (private) railway companies in Prussia, ended in virtually the same way – being taken over by the state and then absorbed into a unified network under the name of the Royal Prussian State Railways or the Royal Prussian Railway Board. The process of restructuring and taking over the railways in Prussia, which was carried out over many years, was a visionary effort and brought benefits for Prussia and later for Germany in every dimension: economic, social or political. By 1890, the length of the state lines was already 23,000 km. Between 1878 and 1918, the Prussian railways made a giant leap forward transforming the country economically and culturally. It resulted in connecting all the district towns of Prussia by rail. The railways dominated both long-distance and local transport as well as the transportation of people and goods. Prussia's railway network during this period is shown in Figure 1.

Locomotives and Rolling Stock of the Partition Period

In Russia, in the early days of railway development, many companies imported rolling stock from England, Belgium and Germany. The first major centre of the Russian railway industry became the St Petersburg-based, state-owned Alexandrovsk Works, founded in 1844. By 1849, 162 steam locomotives and more than 2,500 carriages had been built there. The oldest Russian locomotive was an 1845 passenger steam locomotive with a 2-2-0 wheel arrangement, capable of reaching 40 km/h with a six-carriage train. The next domestic vehicles were passenger steam locomotives with a 1-2-0 and 1 2-1 wheel arrangement, and a freight locomotive with a 0-3-0 wheel arrangement. In Russia, as a result of state decisions, from the late 1860s only locally-produced rolling stock could be used, resulting in the establishment of new factories in such centres as Kolomna, St Petersburg (Neva Works), Bryansk, Kharkiv and Luhansk. In 1906, a record number of 1,300 new steam locomotives were produced. In the case of the Russian Partition, the St Petersburg-Warsaw railway was initially operated by steam locomotives imported exclusively from Western Europe, while after 1890 only Russian steam locomotives were used there. In the case of carriage production in Russia, two Polish manufacturers should be mentioned: Lilpop, Rau i Loewenstein, originating from Warsaw and producing not only carriages but also rails and agricultural machinery, and the Warsaw factory Władysław Gostyński i S-ka producing carriages for the narrow-gauge railway.

In the case of Galicia, the rolling stock used there came from Austrian plants, where locomotive production had already begun in 1839. Manufacturers include, among others, the two largest: The Wien-Raaber-Eisenbahn factory in Vienna and the WienerNeustad locomotive factory. The products of these factories supplied the railway companies in Austria and neighbouring countries and were of course operated in Galicia. Prominent designers of locomotives that were developed in Austria during this period include: Karl Golsdorf, designer of 25 new locomotive series and solutions such as the Gölsdorf axle system or Golsdorf starting system, and Johann Rihosek, born in Maków Podhalański. The steam locomotives of the kkStB270 series (142 units) developed by him ended up in the PKP in 2015, like the Tr12. In contrast, Galicia as a rolling stock manufacturer did not

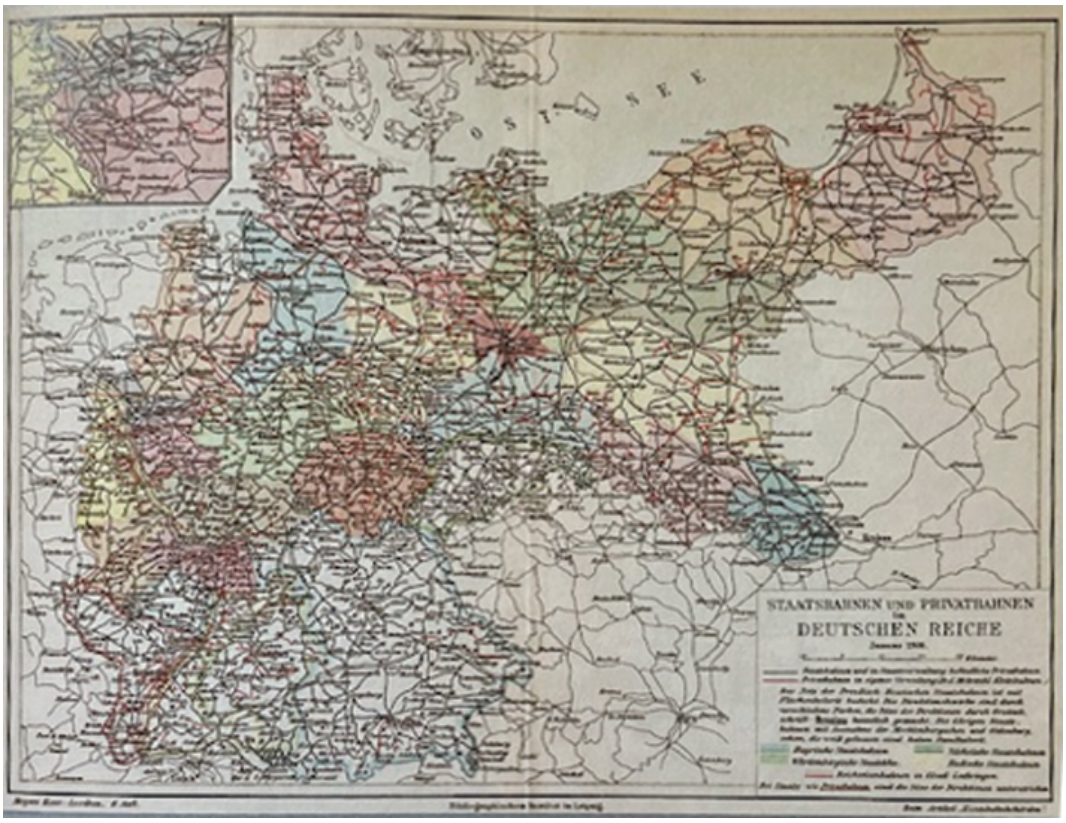


Fig. 1. Prussia's railway network at the turn of the 20th century [2]

play a major role in this area. One manufacturer of, among other rolling stock, was the Pierwsze Galicyjskie Towarzystwo Akcyjne Budowy Maszyn i Wagonów w Sanoku (First Galician Joint Stock Association for the Construction of Machines and Carriages from Sanok), which was known at the time primarily for its contracts with the oil industry.

In Prussia, the first units of rolling stock came from England and Belgium, while the first locomotive manufactured in Prussia was the Borsig steam locomotive, which won a race held on 21 July 1840 on the Berlin-Jüterbog railway against an English locomotive designed by Stephenson. This event can be seen as the beginning of the dynamic development of the rolling stock industry in Germany. The achievements of the rolling stock industry in Germany in the 19th century are among the most outstanding in the world and are difficult to describe in a short article. However, some of them need to be mentioned:

- the T3 series of tank locomotives produced between 1882 and 1910; 1,550 units manufactured at the Henschl works,
- S3-type express train locomotives produced between 1893 and 1904, 1,100 units manufactured at the Hanomag works
- the P8 series of passenger train locomotives; 3,948 units produced mainly at the Berliner Maschinenbau factories in the late 19th and early 20th centuries, and others.

Locomotives and production for railways were also built in the territories now belonging to Poland. These included the factories in Chorzów (Huta Królewska), Wrocław (Linke family works) or the Vulcan-Werft plant in Drzetowo near Szczecin.

This brief overview of the history of the development of the railways on partitioned Polish land was intended to show the state of the railways in Poland at the time of regaining independence in 1918 and to assess the achievements over the next 20 years, which made it possible to build the locomotive that received the highest award at the Exposition in Paris in 1937.

Locomotive builders and designs in the Republic of Poland [2, 4, 11]

An analysis of the conditions in the three partitions shows that the most numerous group of Polish traction system engineers and constructors who influenced the development of the railways in a given partition were the Poles in the Russian Partition. Compared to the other partitions, they played a significant role in the design and construction of new rolling stock and traction system equipment on the Russian railways. Young

Poles from landed gentry families, who did not want to be involved in, for example, farming on the family property, associated their careers with the rapidly developing railways. Due to Russia's significant technological lag and the lack of technical education in Poland, as well as the early development of rolling stock construction in Western Europe, especially in England, Germany and the USA, the main factor in the development of rolling stock in Russia and the construction work of the Poles involved in this process was the creative adaptation of the best Western and American solutions to the Russian railways. As already mentioned, the lack of technical higher education in Poland meant that Poles in the Russian Partition undertook their education at one of the two St Petersburg universities training personnel for the railways: the Institute of Railway Engineers or the Institute of Technology. Both universities represented a high level and their Polish graduates played a significant role first in the development of Russian railways and later in the development of railways in Poland after regaining independence. From the long list of names of talented rolling stock constructors who started their journey at St Petersburg schools and worked as constructors in Russia and ended up working in various positions in independent Poland, one can mention, e.g.:

Wacław Łopuszyński [4] – designer of many steam locomotive concepts for Russian railways, designer of Polish steam locomotive concepts for the Tr21, Ty23 series and co-designer of the OKI27 steam locomotive. He returned to Poland in 1920 and was initially employed by the Directorate of State Railways in Siedlce and Vilnius, and after a year by the Ministry of Iron Railways (Ministerstwo Kolei Żelaznych), where he developed load standards for steam locomotives on Polish railways. As a constructor he was employed in June 1921 at the First Factory of Locomotives in Poland in Chrzanów, known as Fablok. In 1922, he was appointed government commissioner to the Ministry of Iron Railways in Germany and Belgium for the design and acceptance of Tr21 and Ty23 freight locomotives. In 1925, he was appointed a member of the Technical Council at the Ministry of Railways (Ministerstwo Kolei) and also in that year became head of the Steam Locomotive Design Office at the Rolling Stock Construction Faculty of the Mechanical Engineering Department of the Ministry of Railways. He participated in the design work or was a consultant in the design of the OKI27 steam locomotive and the Os24 series steam locomotive for the PKP.

Gustaw Bryling – designer of the Pu29, Ty37, Ty45, Pt47 series steam locomotives and co-designer of the OKI27, Ty57 steam locomotives. He collaborated with Wacław Łopuszański. He came to Poland in 1922, taking up a job at the HCP design office.

Antoni Xiężopolski [4, 7] – co-designer of the OKz32, Ty37 steam locomotives and consultant for the Pt31 and Pm36 designs (Fig. 2). As a graduate of the Faculty of Mechanical Engineering of the St. Petersburg Institute of Technology in 1887, the very next year he began his professional activity at the Aleksandrovsk Machine Building Plant of the Nikolaevskaya railway starting as a steam locomotive fitter before going through all the career levels and gaining invaluable professional experience. After 9 years of work he was already the head of the department responsible for design work related to the repair, modernisation and construction of new steam locomotives, as well as for the modernisation and upgrading of his subordinate department. In 1896, he joined the traction system service of the Nikolayevskaya railway and then, as early as 1897, he was admitted to a state post as a full-time engineer of the 8th class. By decision of the Ministry of Transport, he was sent to the United States, where from 1898 to 1900 he worked at the Baldwin Locomotive Works in Philadelphia designing and building locomotives. In his new position he took charge of the design and production and acceptance of two types of locomotives intended for the strategic Chinese Eastern Railway. During his stay at the Baldwin Locomotive Works, which at the time was one of the largest and most modern steam locomotive factories in the world, Xiężopolski became familiar with American methods of organisation of industry and production. The experience gained at the Philadelphia plant had a very strong influence on the formation of his construction and organisational skills. The next period in Xiężopolsky's professional activity was his work from 1900 as director of the Mechanical Carriage Factory "Dwigatiel" in Reval. In 1903, under the supervision of Xiężopolsky, the design and construction of special and passenger carriages began at these plants. Their construction was carried out almost until the outbreak of the First World War. During the First World War, the works produced arms and ammunition. From 1908 to 1917 Xsiężopolski held the post of director at the Mechanical, Metallurgical and Carriage Works "Fenix" in Riga. After becoming a director, Xsiężopolski modernised and expanded the plant, led to a significant increase in production and expanded the range of products. In 1913, 4,000 freight carriages and 200 passenger carriages were produced in the factory.

When describing the professional activities of Antoni Xiężopolski, it is necessary to mention his teaching work as a lecturer at the Department of Steam Locomotives of the St Petersburg Institute of Technology. In 1896, he began teaching locomotive design and also conducted a course on steam locomotives, and was a member of the State Examination Board. He finished his teaching work after 26 years, in 1921 upon his return to Poland.

Fig. 2. Antoni Xiężopolski, one of the most eminent Polish railway engineers (1861–1951) [4]

Albert Czeczott [1, 4, 6] – designer of many passenger and freight steam locomotives in Russian Empire; he came to Poland in 1923 and became a steam locomotive designer and researcher, expert and counsellor at the Mechanical Engineering Department of the Ministry of Transport. It was due to his efforts that the Experimental Division at the Department of Mechanical Engineering of the Ministry of Transport was established as early as 1923. Albert Czeczott's most important contribution was the development of an innovative steam locomotive traction system testing method, called the "double traction method", which was introduced in 1925 in the PKP and subsequently used in steam locomotive tests by Western railway authorities. In 1933 he supervised the construction of a measurement carriage commissioned by the Romanian railways. During the inter-war period, he conducted research on steam locomotives: Tr21, Ty23, Pm36, and after the Second World War on steam locomotives Ty2/42, Ty4, Ty43, Ty45, Ty246, Tr201/203 and Tr202. The Division headed by Czeczott had a direct impact on increasing the speed and regularity and punctuality of trains on the PKP network during this period. After the war, as early as 1945, he was employed by the Mechanical Engineering Department of the Ministry of Transport, where he established the Experimental Division, becoming its head. In addition to testing typical steam locomotives, the Division was also involved in testing steam locomotives of special design, including the Ty2 steam locomotive. In 1951, the Railway Scientific and Research Institute [9] was established, which acquired all the staff, rolling stock and equipment of the Experimental Division of the Ministry of Transport. Czeczott took over as head of the Steam and Diesel Locomotive Department at the Institute. Under his management, two test trains were organised – one for traction system tests and the other for thermal tests. The established Department took an active part in researching, among other things, the new Polish steam locomotives TKt48, OI49 and Ty51.

The aforementioned Poles represent a small fraction of the Polish traction system or rolling stock engineers who made a very significant contribution to the development of Russian railways and the Russian school of steam locomotive construction. Many of them, after 1918, returned to Poland taking up jobs in various enterprises, factories or government institutions dealing with railways in Poland [2, 4].

In the case of other partitions, one should mention Adolf Langrod [4], who was involved with the Austrian railways after graduating from the Vienna University of Technology and served as commissioning officer of the Austrian railways after graduating and being awarded a doctoral degree in science. In 1919, he was entrusted with the organisation of the Faculty of Construction and Testing of the Mechanical Engineering and Resources Department of the Ministry of Railways. The Department under his supervision initiated many programmes for the construction of Tr21, Ok22, Ty23, Os24 and OKI27 steam locomotives, and reorganised the procurement, production control and acceptance of steam locomotives manufactured for the PKP. At the same time, he carried out teaching activities (initially, from 1947), at the Faculty of Transport of the AGH University of Krakow, where he established the Department of Railway Rolling Stock Construction, later transferred, together with his staff, to the Cracow University of Technology.

2.1. Technical higher education in Poland at the beginning of the 20th century

Departments of Locomotive Construction at Polish technical universities at the beginning of the 20th century

On Polish land, the construction and operation of rolling stock began to be taught in 1901 at the Emperor Nicholas II Warsaw University of Technology, which was established at the time by a decree of the Tsar [2, 4]. On 15 November 1915, under German occupation, the Warsaw University of Technology was established with Polish as the language of instruction. Locomotive construction courses were planned and organised at the Faculty of Mechanical Engineering at that time, but until the return of A. Xiężopolski there were no lecturers in the department.

At the end of August 1921, Xiężopolski returned from Russia and immediately started to establish the Department, whose task was to educate engineers specialising in the construction and operation of rolling stock. He was appointed associate professor on 1 October. On 1 April 1922, by order of the Head of State Józef Piłsudski, he was appointed full professor of locomotive construction at the Warsaw University of Technology. He was also appointed Head of the Department of Locomotive Construction. In establishing a department to

train rolling stock engineers at the Warsaw Polytechnic, and in developing the curriculum, Xiężopolski modelled himself, in terms of the organisation of studies, teaching, lecture topics and equipment, on his home department in St. Petersburg. This was because the lack of Polish models justified such an action. The scope of his studies included issues relating to the design of rolling stock, its maintenance and operation, traction system research, and traction system and workshop management in the broadest sense. Xsiężopolski conducted lectures entitled "Locomotives" for the students of the third and fourth years of study and prepared a textbook, in the form of a script part I and part II, for this lecture in later years (Fig. 3). He also supervised the theses of students working on steam locomotive projects. Each student had to complete a project independently and drive a steam locomotive for at least six weeks before taking the diploma exam. Students also completed internships in railway laboratories, factories and workshops.

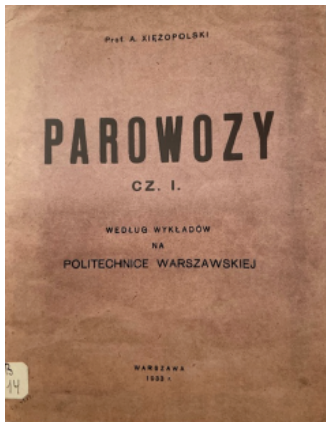


Fig. 3. Cover of the script by prof. A. Xiężopolski for the course on steam locomotives, part I [4]

Thanks to his connections in the locomotive design community, prof. Xiężopolski invited prominent practitioners, designers and professors such as Albert Czeczott, Mieczysław Gronowski, Wiesław Chrzanowski, Anatol Bogolubow-Bieliński and Roman Podoski to conduct lectures for students with major in locomotive construction. In 1932, professor Xiężopolski reached retirement age, but at the request of the Senate of the Warsaw University of Technology, the Minister of Religious Affairs and Public Education extended his employment. Finally, in 1935, Xiężopolski ended his teaching career, handing over the Department to his student Kazimierz Zembrzuski.

In addition to his teaching work, prof. inż. Antoni Xiężopolski was very active professionally. Immediately after his return from Russia, he was appointed to the Committee of the Ministry of the Treasury for the Liquidation of Post-War German Property. He was in charge of the liquidation of mainly railway establishments; on 11 December 1924, the Committee for the Development of Rolling Stock and Mechanical Railway Equipment of the Ministry of Railways was established. Professor Xiężopolski became the representative of industry and technical universities on this Committee. Meetings of the Committee were held very frequently (usually every month) and the matters discussed were the development and modernisation of steam locomotive construction, the execution of designs for new steam locomotives and the supervision of their construction. In April 1925, a resolution of the Council of Ministers established the Technical Board under the Minister of Railways to consider technical matters of general importance and major projects and their determinants. The Council was the highest advisory body to the Minister on technical matters. Prof. Xiężopolski became a member of the Council in 1927. At the same time, he became a regular consultant on the construction of new types of rolling stock in the 6th Department of Mechanical Engineering and Railway Resources of the Ministry of Railways. From that time onwards, he consulted on projects carried out at Fablok and the H. Cegielski works, shaping the policy on the design and purchase of rolling stock for the PKP. He participated as a consultant and opinion maker on such steam locomotive projects for the PKP as Pu29, Pt31, OKz32, Pm36, Ty37 and industrial, export and narrow-gauge steam locomotives. The Mechanical Engineering Department of the Ministry of Railways entrusted him with the handling of complex issues relating to the construction of rolling stock, as well as the opinion and selection of the best foreign technical solutions that could be adopted in the country. On behalf of the Ministry of Transport, he carried out the final verification of steam locomotive construction documentation and also approved it on behalf of the Ministry. For his activities for the railways, he was honoured with, among other things, the Golden Cross of Merit, awarded in 1937 by the President of the Republic of Poland.

The training of railway engineers specialising in traction systems also began in the Austrian partition. In 1910, the Department of Railway Machine Construction was established at the Lviv Polytechnic School, with prof. inż. Zygmunt Sochacki as its head and, following his retirement in 1921, prof. inż. Wilhelm Mozer taking over the chair. In addition to his teaching activities, he worked as a technical consultant for Polish rolling stock factories such as [2, 8]: Fablok, HCP or PZInż. in Ursus. W. Mozer worked on a new curriculum for railway studies, introduced from the academic year 1928/1929. He was also the author of numerous textbooks on the design and construction of steam locomotives. After the Second World War, he continued to head the Department of Thermal Power, Boilers and Turbines of the Lviv Polytechnic Institute until 1958.

In the Prussian Partition, future Polish engineers were educated at German technical universities. After regaining independence, many Poles studied at the German Technische Hochschule Danzig (Free City of Gdańsk). The Faculty of Mechanical Engineering housed the Department of Railway Vehicle and Steam Boiler Construction. In the mid-1930s, there were 1,500 students at this university, including 370 Poles.

Pm36 steam locomotive – history of construction development

The history of the construction of the Pm36 steam locomotive is inextricably linked with the figure of Kazimierz Zembrzuski (Fig. 4), a graduate of the Faculty of Mechanical Engineering at the Warsaw University of Technology [5]. He graduated in 1929 from the Department of Locomotive Construction of the Faculty of Mechanical Engineering at the Warsaw University of Technology. He graduated under the supervision of professor Xiężopolski. Already in the years 1928-1929, he worked at the Experimental Division at the Department of Mechanical Engineering of the Ministry of Transport, headed by Albert Czeczott, taking part in research on steam locomotives. After graduating, he worked briefly as a constructor at the Warszawska Spółka Akcyjna Budowy Parowozów. At the age of 25, recommended by prof. Xiężopolski, he started working in the Technical Office of the "Fablok" steam locomotive factory in Chrzanów, i.e. in the design office of the factory [5, 8].

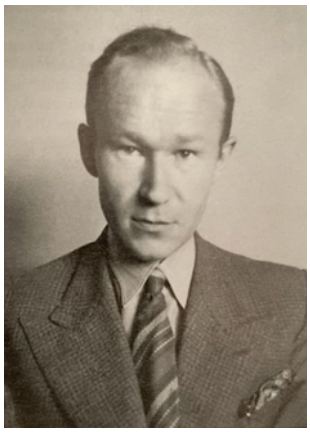


Fig. 4. Kazimierz Zembrzuski (1905–1981); photo from the period of his work at Fablok [5]

He was initially assigned the task of pre-designing a Pt-type express steam locomotive for the Polish State Railways (PKP) based on guidelines from the Ministry of Transport. Within a few weeks he had carried out calculations and developed the characteristics of the steam locomotive and designed the boiler. The developed materials were sent to the Ministry of Transport where they received a strongly positive opinion from prof. Xiężopolski.

In June 1930, Fablok concluded a contract with the Bulgarian Railways for the delivery of 12 steam locomotives. Kazimierz Zembrzuski was included in the team appointed to develop the structural design and execution of this order, dealing with the development of the layout of the boiler fittings and other equipment on the steam locomotive, located on the boiler walls in the driver's cab, and checking the executive drawings of this steam locomotive. During the course of the project, in the middle of 1930, the previous head of the Office resigned from this position for health reasons. This position was offered to inż. Zembrzuski and, at the age of 25, he assumed the leading role of the construction team, which came as a great surprise and challenge to him. In mid-1931, the Bulgarian steam locomotive passed its tests and was received by the commissioning officer (Fig. 5).

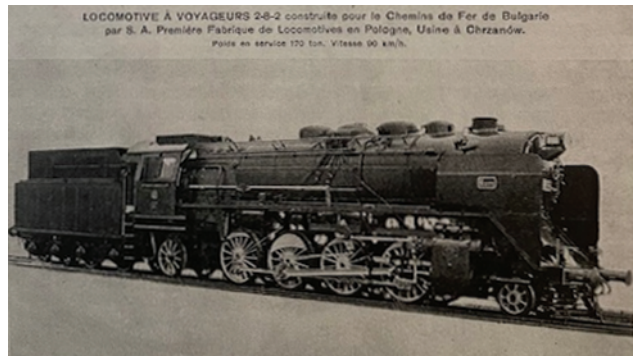


Fig. 5. Steam locomotive for Bulgarian railways manufactured at Fablok, 1930 [2]

The head of the Office, inż. Zembrzuski, also participated in the tests. In parallel with his current activities, in the early spring of 1931, he began further work on the preliminary design of the Pt steam locomotive, which had already been given the name Pt31. Zembrzuski personally developed the overall design of the steam locomotive, including calculations and description. He always made sketches of the technical drawings by hand (Fig. 6). In June 1931, the developed material was sent to the Ministry of Transport, where it received approval and, as a result, Fablok received an order for three prototype steam locomotives. At the end of 1932, after testing, the three Pt31 steam locomotives were commissioned and entered into service for the PKP (Fig. 7a, b). This was a success for both the locomotive factory in Chrzanów and inż. Zembrzuski. By the outbreak of war in 1939, 100 Pt31 steam locomotives were already operating on the main lines of Polish railways in express passenger transport.

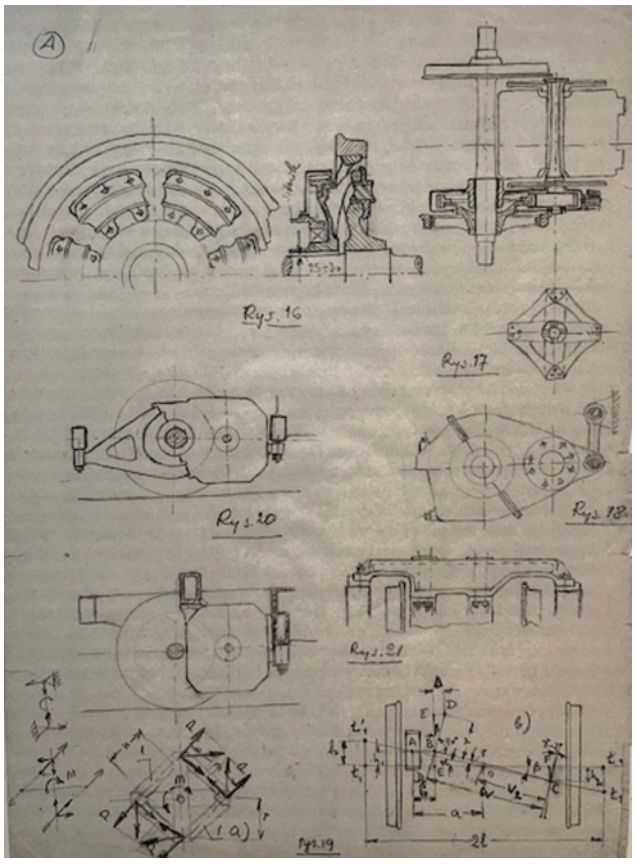


Fig. 6. An example of a handwritten sketch made by prof. K. Zembrzuski [5]

In the middle of 1935, during one of his visits to the Fablok, prof. Xiężopolski informed inż. Zembrzuski that he should undertake work on the development of a conceptual design for a steam locomotive with a standard structure, but faster than the Pt31. He also informed him of the situation regarding the personnel that would arise in the following year in the Locomotive Construction Department, due to the retirement of the department's head, prof. Xiężopolski. He thus encouraged him to apply for the soon-to-be-announced vacancy in the department.

When commencing work on the new steam locomotive in mid-1935, inż. Zembrzuski made preliminary assumptions, shown in Figure 8, and concluded that the pressure of the drive wheels on the rails should be no greater than that found in the solutions of Western steam locomotives of a similar class, and that the shape of the steam locomotive should be streamlined and the driver's cab enclosed. He estimated the maximum speed at 140 km/h. The materials sent to the Ministry of Transport were approved by the Technical Council at the Ministry of Transport, and in August 1936 Fablok received a formal order for the construction of two steam locomotives named Pm36, differing in their external design. At the same time, it was reported that the Fablok Board intended to take part in the International Exposition in Paris in the spring of 1937 to present two steam locomotives, Pt31 and Pm36 – with streamlined shapes. Work on the Pm36 steam locomotive commenced on 1 September 1936 and almost simultaneously, on 1 October, prof. Zembrzuski started conducting lectures at the Technical University.

In early April 1937, work on the Pm36-1 steam locomotive was completed (Fig. 9). Trial runs in the Chrzanów area and on the Kraków-Lviv railway proved that the requirements were met, and in July of that year the Pt31 and Pm36-1 steam locomotives were shipped to Paris (Fig. 10), arousing great interest on the way (in Germany) from German railwaymen, who could not believe that this could be the design of a Polish engineer.

Exhibited at the Polish Ministry of Transport exhibition, the Pm36-1 locomotive with aerodynamic cover, designed by the Institute of Aerodynamics of the Warsaw University of Technology, won a gold medal, becoming one of the symbols of Polish modern engineering solutions and Polish modernism of the inter-war period in industrial design.

a)

b)

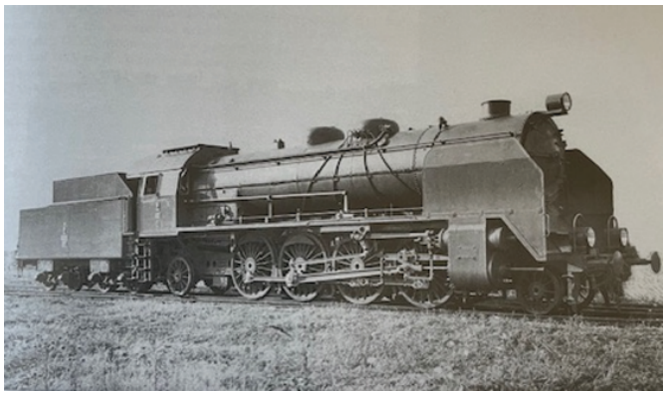
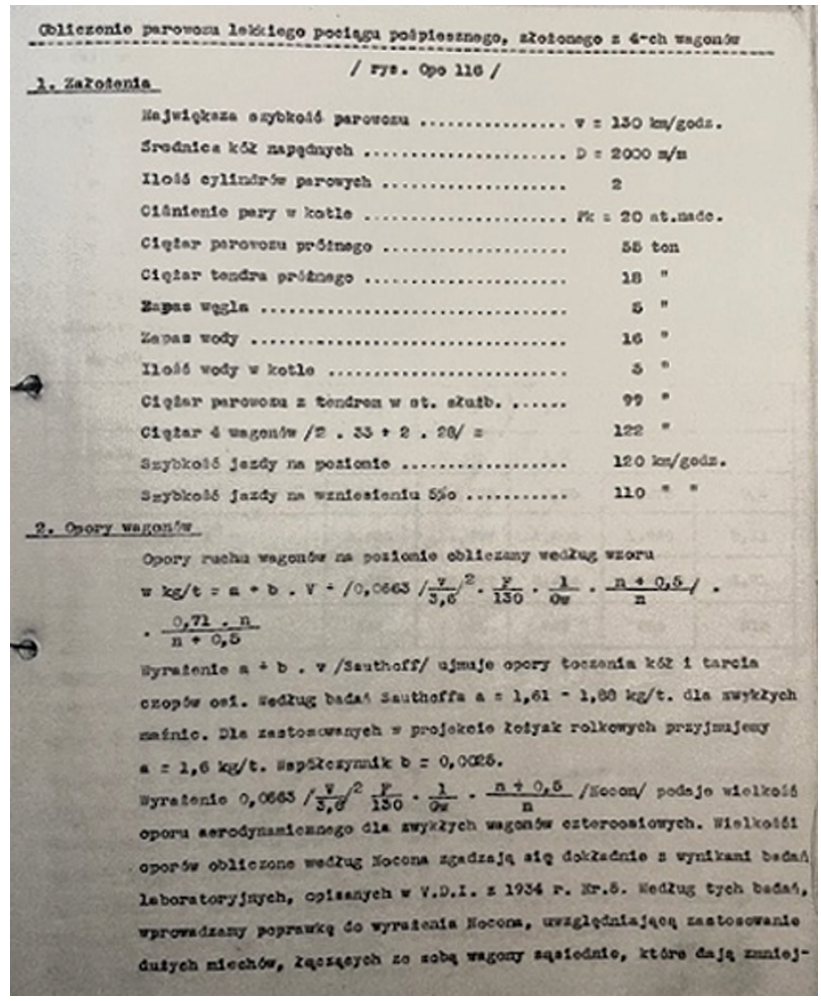


Fig. 7. (a) prof. Xiężopolski with Fablok employees after steam locomotive tests; inż. Kazimierz Zembrzuski, fourth from left [4, 5], (b) Pt31 steam locomotive [4]



Obliczenie parowozu lekkiego pociągu pośpiesznego, złożonego z 4-ch wagonów

/ rys. Opo 116 /

1. Założenia

Największa szybkość parowozu	v = 130 km/godz.
Średnica kół napędnych	D = 2000 m/m
Ilość cylindrów parowych	2
Ciśnienie pary w kotle	Pk = 20 at.nadc.
Ciężar parowozu próżnego	55 ton
Ciężar tendra próżnego	18 "
Zapas węgla	5 "
Zapas wody	16 "
Ilość wody w kotle	5 "
Ciężar parowozu z tendrem w st. służb.	99 "
Ciężar 4 wagonów /2 . 33 + 2 . 28/ =	122 "
Szybkość jazdy na poziomie	120 km/godz.
Szybkość jazdy na wzniesieniu 5‰	110 " "

2. Opory wagonów

Opory ruchu wagonów na poziomie obliczamy według wzoru

$$w\ kg/t = a + b \cdot V + /0{,}0663 /\frac{v}{3{,}6}/^2 \cdot \frac{F}{130} \cdot \frac{1}{Gw} \cdot \frac{n + 0{,}5}{n} / \cdot \frac{0{,}71 \cdot n}{n + 0{,}5}$$

Wyrażenie a + b . v /Sauthoff/ ujmuje opory toczenia kół i tarcia czopów osi. Według badań Sauthoffa a = 1,61 - 1,80 kg/t. dla zwykłych smarnic. Dla zastosowanych w projekcie łożysk rolkowych przyjmujemy a = 1,6 kg/t. Współczynnik b = 0,0025.

Wyrażenie $0{,}0663 /\frac{v}{3{,}6}/^2 \frac{F}{130} \cdot \frac{1}{Gw} \cdot \frac{n + 0{,}5}{n}$ /Nocon/ podaje wielkość oporu aerodynamicznego dla zwykłych wagonów czterosiowych. Wielkości oporów obliczone według Nocona zgadzają się dokładnie z wynikami badań laboratoryjnych, opisanych w V.D.I. z 1934 r. Nr.8. Według tych badań, wprowadzamy poprawkę do wyrażenia Nocona, uwzględniającą zastosowanie dużych miechów, łączących ze sobą wagony sąsiednie, które dają zmniej-

Fig. 8. Preliminary assumptions for the Pm steam locomotive [5]

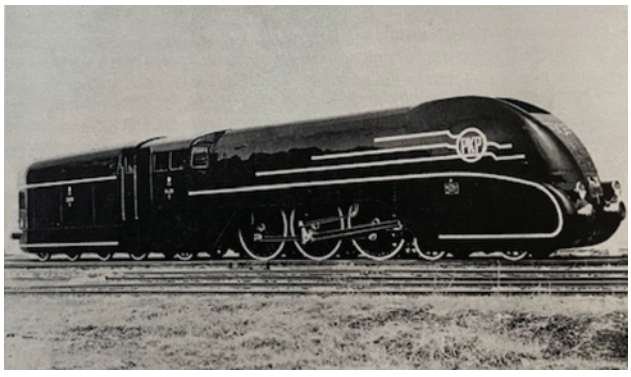


Fig. 9. Pm36 steam locomotive with aerodynamic cover [2]

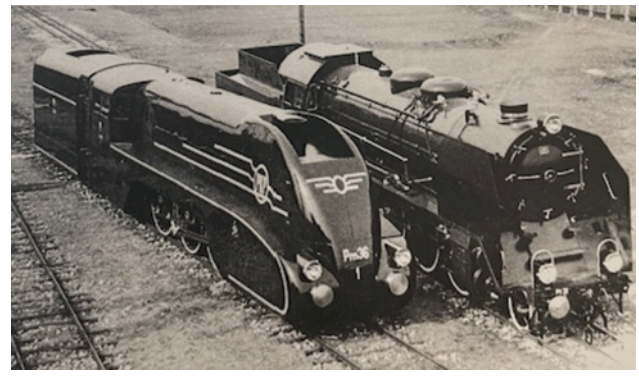


Fig. 10. Pm36-1 and Pt31 steam locomotives moments before departing for the International Exposition in Paris, 1937 [3]

The Pm36-1 steam locomotive was placed at the Warszawa Zachodnia, Białystok and Kutno steam locomotive depots, being constantly under the observation of Albert Czeczott's Experimental Division. During operation at the latter, the machine accelerated to 142 km/h while carrying a 400-tonne train. After testing, the machine was assigned to run the Nord Express luxury train on the Kutno – Poznań – Zbąszyń section. The second locomotive, the Pm36-2, was completed in June 1937. This locomotive was also subjected to tests, which included a draw gear with two chimneys and an accelerated brake.

After returning in 1938 from the Paris exhibition, comparative tests were carried out on a section of the Warsaw-Turmont line between Białystok and Vilnius on two units of the Pm36 series express steam locomo-

tive: with and without streamlined cover. They were carried out by a team from the Experimental Division of the Ministry of Transport, led by professor A. Czeczott. According to the research programme, the steam locomotives were to run express trains at the highest commercial speed in Poland on this section. On behalf of the Fablok, inż. Gieżyński was delegated for the entire duration of the tests, while the steam locomotive's designer, inż. K. Zembrzuski, also participated on several occasions [5]. Confirmation of the tests of Pm36 locomotives on the former St Petersburg-Warsaw main line is evidenced by their listing as assigned at the time (for example, in July 1938) to the Vilnius Directorate, to the steam locomotives depot in Białystok.

The story of the Pm36-1 locomotive after the war, is not known in detail. Various sources provide contrary information. Work [2, 7] reports that captured by the Red Army in Germany, it was scrapped in 1952 on the Baltic railway, while German sources report that in 1942 it was transferred to the German railway research centre LVA in Grunewald and scrapped there after being dismantled into parts. On the other hand, a model of Pm36-2, which was given the 'nickname' Beautiful Helen (Piękna Helena), was operated regularly by the PKP after the war, with the number Pm36-1, until 1965. After its operation ended, it was handed over to the Wolsztyn steam locomotive depot in 1995, where it ran tourist and special trains. The steam locomotive is currently placed in Wolsztyn (Leszno?) awaiting repairs.

In 1945, after the war, prof. Zembrzuski, the constructor of the Pm36 locomotive, was delegated by the Ministry of Education to the Łódź University of Technology, where as Dean he organised classes at the Faculty of Mechanical Engineering. In 1948 he was transferred to the Warsaw University of Technology to take charge of the Department of Locomotive Construction, renamed in 1961 as the Department of Rail Vehicles. He organised the work of the Department and teaching activities in the field of rail vehicles, additionally fulfilling various functions within the structure of the Faculty and University (Head of the Department, Deputy Dean, Deputy Rector, Member of the Senate). He retired in 1971, continuing to teach at the Faculty to a limited extent.

At the same time, after the end of the war, he began a busy career. In 1946, he was appointed technical consultant to the Department of Mechanical Engineering at the Ministry of Transport. He held this position until mid-1951. In the following years, he was involved, among other things, as a member of the Technical and Economic Board to the Minister of Transport, as a member of the Scientific Council of Central Research and Development Centre for Railway Engineering (COBiRTK) and permanent consultant at the Department of Railway Vehicles of Central Research and Development Centre for Railway Engineering, as well as a consultant on rail vehicles at the Central Design Office (CBK) of PKP in Poznań.

3. Conclusions

Such dynamic development of modern locomotive construction and the rolling stock industry as was seen in the first 20 years after Poland regained independence did not occur again later in Polish history. The steam locomotive constructions built at that time in no respect differed in their solutions from those built in Western countries or America. An example of this is the Pm36 steam locomotive, named the "Beautiful Helen", the design of which set the standards for light locomotives intended for passenger transport for many years to come. The locomotive designers of this period also played a significant role in the education of mechanical engineers at technical universities in Poland, both before and after the Second World War.

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