The Place and the Role of Narrow-gauge Steam Locomotive Production in the History of Hungarian Industry

PhD Dissertation

Motto
"There be three things which make a nation great and prosperous, — a fertile soil, busy workshops, and easy conveyance for men and commodities from one place to another."

Lord Bacon

Thanks to William Allen for assistance with the English text.

The place names used in the dissertation are those in use officially at the time they are referred to in the text.

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Introduction

Having overcome all the difficulties caused by the revolution and the war of liberation 1848-49, the Compromise of 1867\(^1\) regularised the political and economic relations between Austria and Hungary and the industrialisation started in the old Kingdom of Hungary. New factories were built, increasing the industrial production year by year which required more and more coal for feeding the newly built steel furnaces and boilers of the steam operated machinery. New coal mines were opened after 1867. The opening and rapid development of coal fields demanded new means of transportation, instead of horse drawn carriages and heavy wagons running on dusty roads, on which the traffic was influenced by the extreme weather conditions of the Carpathian-basin\(^2\). New railways were built between the collieries and the steel workshops or the loading points. These railways had narrower track gauge than 1435 mm, standardised in England for public passenger service, and were operated by horse drawn trains. However, horsepower was not enough to fulfil the increasing transportation demands, therefore steam engines were put into service, replacing the horses on the busiest colliery lines in Hungary from 1870, only a few years after steam traction was introduced on the Ffestiniog Railway in Wales. Public passenger and freight traffic started on the meter gauge Garamberzenz—Selmecbánya Local Railway on 10\(^{th}\) of September 1873, besides the steam operated colliery and industrial lines. The Local Railway was operated by the Magyar Királyi Államvasutak (Royal Hungarian State Railways - MÁV). The length of Hungarian narrow-gauge network exceeded 300 km at the end of the 1880s\(^3\). The narrow-gauge local railways became very popular in Hungary by the end of the century, even though the Hungarian Parliament supported the construction of English standard gauge secondary lines connected directly to the national network They provided the same quality of service as the standard gauge secondary lines, with lower investment and operational costs. The total length of the industrial and public narrow-gauge network reached 6700 km by the end of the First World War in 1918, and 3850 km of it was operated by steam locomotives. At that time the Hungarian standard gauge network was 18 000 km long.\(^4\)

After the end of World War 1 Hungary lost two-thirds of its territory, but the construction of new narrow-gauge railways continued inside the new Trianon borders. Besides the more than 8000 km standard gauge network, the length of the Hungarian narrow-gauge lines was estimated at 6000 km after WWII including the short, few hundred meters long, industrial lines operated inside factories and workshops, the short networks of agricultural, forest, colliery and industrial railways and the large, 100-200 km long local network of public railways. Planes were also made to connect the narrow-gauge local networks to create a national narrow-gauge system, alongside the operating standard gauge network, but the lines were operated separately with few exemptions. Their transportation capacity was different according to the duty they served, but the transportation performance of the busiest lines exceeded some local networks, and some reached 5-600 000 t per year.

The first narrow-gauge steam locomotives, put into service in Hungary, were built by foreign locomotive manufacturers in 1870. The very first steam locomotive built Hungary was designed by John Haswell and put into operation on the 950 mm gauge Resica Iron Factory of the Állami

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1 The Compromise of 1867 was the result of the long discussions and negotiations on the new political and economic relations between Austria and Hungary. It was codified by the Hungarian Parliament in the Act XII of 1867 completed by the Acts XIV, XV and XVI of 1867.

2 The spring floods and heavy autumn rains influenced extremely the traffic conditions in the Carpathian basin. - Vass Tibor. *Az Ózdi iparvasút története (The History of Industrial Railways of Ózd – in Hungarian)*, 2001. Budapest, Közlekedési Múzeum, p. 18.

3 Vörös László szerkesztő: *Magyar Vasúti Évkönyv VI, (Railway Yearbook VI - in Hungarian)*, 1883, Budapest

4 Szatmári Mórá szerkesztő: *Közlekedési évkönyv az 1917. évről (Transportation Yearbook, 1917 – in Hungarian)*, Wodianer és fiai, Budapest, 1918
Vaspályatársaság (State Railway Company - ÁVT - Staats Eisenbahngesellschaft – StEg in German), in 1872. Two new narrow-gauge locomotives were put into service on the 790 mm gauge network of Salgótarjáni Kőszénbánya Rt., (Salgótarján Coal Mine Company), in 1876. The locomotives were built in Budapest by the MÁV Machine Factory and were the first steam engines designed by Hungarian locomotive manufacturers. Soon the MÁV Machine Factory, later the Magyar Királyi Állami Vas- Acél- és Gépgyárak (MÁVAG) in Budapest, became the most important locomotive builder in Hungary, but some other factories, and railway workshops also manufactured steam locomotives. The Hungarian locomotive factories had an important role also in the manufacturing of steam engines designed for the 760 mm gauge public network built in the Bosnian-Herzegovinian province, which was unique in Europe at that time. Its length exceeded 2000 km after the opening the Beograd—Sarajevo line. The transportation performance of the formal Bród—Szarajevo main line exceeded the performance of some standard gauge main lines of the Monarchy, offering the same quality of comfort and travelling speed.¹

Eleven steam locomotive builders: machine factories, railway workshops, and workshops, built more than 7760 steam locomotives in Hungary, between 1872 and 1959. More than 1050 were narrow-gauge among them.

The aim of the dissertation:
- Introduction the history of Hungarian narrow-gauge steam locomotive manufacturing in a scholarly way,
- The study of the relationship between the narrow-gauge locomotive production and the Hungarian Industry in the historical ages of 1872 and 1959,
- Determining the place and role of narrow-gauge steam locomotive production in Hungary, in the Carpathian basin and in the successor states of the Austro-Hungarian monarchy,
- The comparison of narrow-gauge locomotives designed and built in Hungary with the characteristic foreign types.

Examination of the condition of steam traction today, which characterised land transportation through 150 years following the industrial revolution, and looking for the possible solutions, in order to maintain the operation of steam locomotives for the next generations

¹ The scheduled journey took 21 hours 56 minutes on the 548 km long, 760 mm gauge, Boszna-Bród—Szarajevó—Gravosa (Dubrovnik) line, with 25 km/h mean speed by the fast trains of Bosznia-Herzegovina Országos Vasutak (BHOV), in 1902. The journey time of the fast service on the 29 km longer Bécs—Trieszt line was 21 hours 10 minutes including the time for taking water and standing at the stations. It corresponds to the mean speed of 27.2 km/h. The number of trains on the Zsenica—Szarajevó line section, characterising the traffic of BHOV, was 60 per day. The freight performance of 269 km long Boszna-Bród—Szarajevó line was 800 000 t per train kilometre. Based on figures in 1903 this performance reached 1 100 000 t, exceeding the performance of the standard gauge Wien—Aspang Bahn, considerably and approaching the performance of the busiest main lines of the Monarchy. — Reise-Eindrücke von J. R. v. Wenusch: Eisenbahnen von Dalmatien, Bosnien und Herzegovina (Railways of Dalmatia, Bosnia and Herzegovina – in German). Wien 1903
The applied methods of dissertation: *statistics, case studies, comparison and analysis* of technical features of specified Hungarian and foreign types of steam locomotives using the different published methods and calculation systems.\(^6\),\(^7\),\(^8\)

To make the comparison and the calculations easier, I will use the old measuring system of technical literature and the ordinary technical parameters instead of SI units. The effective tractive efforts of the locomotives are calculated on flat and straight tracks.

The detailed calculations, technical parameters of locomotives and the description of examined railway lines can be found in the Annexes. None of the detailed calculations and comparison of narrow-gauge steam locomotives have been made before. Any dissertation analysing the relation of Hungarian industry and narrow-gauge steam locomotive production has never been made before.

**Elaborated sources:**
- Documents of Archives,
- Technical literature,
- Articles, studies published in the medium of the press,
- Manuscripts,
- Photo collections,
- Photo archives.

The references to the technical literature and the footnotes are indicated by numbers in superscript and can be found in the text.

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\(^7\) Kopasz Károly: *Gőzmozdonyok, (Steam Locomotives – in Hungarian)* Tankönyvkiadó, Budapest, 1960

\(^8\) Hajnócz László: *Gőzmozdonyok, (Steam Locomotives – in Hungarian)* Felsőoktatási jegyzetellátó vállalat, Budapest, 1956
2 Evolution of Steam Operated Narrow-gauge Railways

The English Parliament passed the “Act for regulating the Gauge of the Railways” on the 18th of August 1846, ending the competition of the Railway Companies using different gauges on the British Isles. Although the result of the experiments and the technical features suggested the operation of 7 Feet ¼ Inches (2140 mm) gauge lines, the Parliament standardised 4 Feet 8½ Inches (1435 mm) gauge for the construction, renewal and extension of railways for the conveyance of passengers in Great Britain. The 4 Feet 8½ Inches (1435 mm) gauge was introduced by Robert Stephenson & Co. It originated in the Hetton colliery line - where George Stephenson built his first successful steam locomotives - and was increased by half inch later.9 10 Railway lines were built with different gauges before and after, but from that time the railways of smaller gauge tracks than the standard are called narrow, and of wider gauge tracks are called broad gauge. The rolling stock, running on the different gauge lines, is also classified as narrow, standard and broad-gauge vehicles.

The decision of the British Parliament established the principle of standardised gauge railway systems, which determined the construction of national standard gauge railway networks and kept hindering the general use of narrow-gauge railways until the end of the 19th century, when narrow-gauge was irreversibly sidened from passenger service.11

The opening of the Stockton & Darlington Railway, steam traction’s first introduction to the general public on 27th of September 1825, was the beginning of a long and successful story. It originated the England of the 16th century, when Queen Elisabeth I ruled the kingdom of England and Ireland on the British Isles. While the kingdoms of the Continent were fighting with each other or led unsuccessful military expeditions against the Ottoman Turk Empire in the Balkans at that time, England was the lord of the seas having defeated the great Spanish Armada in 1588. London was the centre of world trading and home of the East India Company. The maintenance of the British colonial empire, the social, economic and financial changes generated by the active trading started an industrial revolution in England, which had not been seen in the earlier history of mankind.12 Queen Elisabeth I imported German miners for mining and

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9 George Stephenson adopted 4 Feet 8 Inches (1422 mm) gauge, when he built his Hetton Colliery Railway Locomotives, but later he increased it by ½ Inch, and consequently used it for the construction of new railway lines. The length of 4 Feet 8½ Inches (1435 mm), then so called, narrow gauge railways was more than 3000 km, compared to the 440-km length of broad gauge in England, in 1846. The general invention of broad gauge required much more money, than the possible savings would have generated by the operation of Isambard Kingdom Brunel’s 7 Feet ¼ Inches (2140 mm) network of better technical features. - Gauge Evidence - The History and Prospects of the Railway System Illustrated by the Evidence Given before the Gauge Commission. by Samuel Sidney, London, Edmonds, 154, Strand and Vacher, Parliament Street. 1846.

The Parliament standardised also the 5 Feet 3 Inches (1600 mm) broad gauge for the railways in Ireland by this decision. — An Act for regulating the Gauge of Railways, CAP LVII, 18. August 1846, Nagy Britannia Parlamentjének Archivuma, London


11 The passengers had to change the trains at the connecting stations of railways built with different gauges. The freight must be reloaded between the wagons. Changing trains caused a lot of trouble, the reloading of freight lost time and cause extra expenditure. The trains could run without obstacles, excluding the restrictions, on the standard gauge networks.

12 John Lord: Capital and Steam Power 1750-1800 London, 1923 University Library, Rochester
the utilisation of British Isles’ mineral resources. They brought with them the knowledge of constructing and using wooden plate ways.\textsuperscript{13,14}

The wooden plate ways, used only underground before, appeared on the surface between the pit-heads and river loading points in England, in the second half of 17th century.\textsuperscript{15} The transportation on the surface became independent of the weather conditions. The horses could draw heavier loads on the tramways constructed with wooden plates and beams. The wagons carried two tons of loads on the wooden tramways. The traction of them required significantly less effort, than on the pot holed, muddy roads. Therefore, two or three wagons could be coupled together composing trains, and easily drawn by a horse, where it was possible.\textsuperscript{17}

The production of raw materials for manufactures was interrupted by water frequently intruding the mines. Captain Thomas Savery constructed a pump operated by steam in London to make the miners’ work easier and established a factory for the production of his engines in 1699. The capacity of Thomas Savery’s steam engine, that did not have piston, was significantly limited by the capability of vacuum. The pumping depth could have been increased from 10 m up to 15 m by a using a high-pressure boiler, but this was not safe at that time.\textsuperscript{18} \textsuperscript{19}

A new piston pump engine, operated by steam, was put into service in one of the mines of Dudley Ten Yard, near Birmingham in 1712. Thomas Newcomen, the inventor, utilised the idea of Denis Papin who discovered the vacuum’s working capability, and his steam pump could lift 2 m$^3$ of water from the deep mines by one nodding of its beam. \textit{120 of Newcomen’s steam engine were pumping the water on the mining areas in Great Britain in 1769, when James

\textsuperscript{13} In 1564 Queen Elizabeth set up the “Company of Mines Royal”, a state monopoly, to mine copper to make the brass cannon needed for the Royal Navy. Copper had been mined in the English Lake District since at least 1125, but by the mid-16th Century the easier to mine seams were exhausted. Mining started at Caldbec in Cumbria (Cumberland) in 1566 under a German/Austrian, (most probably Austrian) miner named Daniel Höchstetter. Mining continued intermittently until 1630. Of the approximately 150 men who are known to have come to England from the continent we know the origin of 38 and 35 of these came from the Tirol.

\textsuperscript{14} The tramway consisted of plates laid down parallel to each other in a determined distance and fastened by cross beams underneath, like today’s railway tracks. The miners carried the ore to the surface moving small, four wheeled wagons on it. — Dr. Horváth Ferenc: \textit{A magyarországi vasúti pályák építése (1827-1875) (Construction of railway tracks in Hungary (1827-1875) – in Hungarian)}, Dr. Kovács László főszerkesztő: \textit{Magyar Vasútőrténet a kezdetekől 1875-től} (The History of Hungarian Railways from the Beginning to 1875 – in Hungarian), Budapest, MAV Rt. 1995, p. 109.

\textsuperscript{15} The fuel supply of the fast-growing cities increased the demand for coal, because there was little woodland in England, but that good trees were reserved for the Royal Navy. Also, most of the country used timber for framing houses. In the south of England, the woodland on the South Downs had been destroyed by charcoal burning for the Sussex iron industry, which had been going on since pre-Roman times. This meant wood for fuel was in short supply, especially in cities like London. Coal for London had been sent from Newcastle by ship, called colliers, since the beginning of the 13th Century, and it has been estimated that by 1700, 500,000 tons of coal a year was being imported to London from the North-East. - \textit{London, a History, Francis Shepherd, Oxford UP})

\textsuperscript{16} The poor conditions of road transportation hindered the growth of coal consumption. However, England had large network of inland waterways, consisted of rivers and canals in the 18th century, the coal was transported from the collieries to the water loading points on roads by horses and wagons. The frequent rainfall in the British Isles, which made possible the construction of large network of canals, made a sea of mud of the public roads requiring permanent maintenance. — Csíkvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 27

\textsuperscript{17} Csíkvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 27-28.

\textsuperscript{18} Csíkvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 45-46.

\textsuperscript{19} Thomas Savery: \textit{The Miners Friend, or an Engine to Raise Water by Fire}, London, 1702 Egyetemi könyvtár, Rochester
Watt registered his first patent. James Watt improved the Newcomen steam engine operated by vacuum, but his most important invention was the conversion of pistons’ alternating motion to rotation, noticed in 1781.\textsuperscript{20, 21}

The steam engines of Boulton & Watt Co. providing rotating motion, soon replaced the waterwheels for driving the hammers and bellows of the iron works’ forge shops and the looms of textile factories. Factory production became independent of the water output of the rivers. The steam engines could be set up anywhere, so the forge workshops and the industrial plants were not linked to the banks of rivers anymore. \textit{James Watt’s steam engines made it possible for Henry Cort to introduce rolled steel profile production. His other invention, the introduction of the puddling furnace was also a revolution in steel production}.\textsuperscript{22}

The increasing number of steam engines, the inhabitants of fast growing cities, and the introduction of Henry Cort’s new puddling furnaces - requiring four or five times more coal for steel production than pig iron\textsuperscript{23} - increased the demand for the coal mined in the collieries. The steel tyres of heavy wagons, loaded with coal, wore out the wooden plate ways; therefore it was necessary to frequently change and repair them. The experiments for decreasing the maintenance demand of tramways led to the evolution of railways by the end of the 18th century.\textsuperscript{24}

With the introduction of wagons equipped with flanged wheels, running on iron rails laid down parallel to each other, a new means of land transportation was born, which significantly increased the transportation capacity of the roads.

\textbf{The common use of colliery tramways like canals and public roads was requested frequently. This demand was increased in case of railways operated by horses.}

The Surrey Iron Railway was put into service and opened for the public on 26. July 1803 within the boundary of today’s London. The Railway, operated by horses, transported the products of factories and mills of the Wandle river valley to the port on the bank of the river Thames. \textbf{A new category of railways, the public railway, appeared by opening the Surrey Iron Railway besides the private railways used for industrial transportation only.}

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\textsuperscript{20} Csikvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 51-53.
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\textsuperscript{21} The crank, for converting linear motion to rotary motion, was first patented by James Pickard in 1779. He had set up an Engine at Snow Hill, Birmingham in early 1779, the builder being Matthew Wasbrough. Watt always argued that Pickard stole the idea from him. This is unlikely as Boulton & Watt were very keen on protecting their ideas and patented everything as soon as they could. Watts’s 1782 patent was for the sun & planet motion. \textit{- James Watt & the Steam Engine by HW Dickinson & R Jenkins, Moorland Publishing 1927, reprint 1981.}
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\textsuperscript{23} D. Török Béla: \textit{A vaskohászat története a XIX. század második felében az ózdi gyár aspektusából (The History of Iron Metallurgy in the second Half of 19th Century from the Point of View of Ózd Factory – in Hungarian)}, Miskolci Egyetem Műszaki Anyag tudományi Kar, p. 7
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\textsuperscript{24} The wooden plates of the tramway, running from Coalbrookdale Ironworks near Birmingham to Horsley colliery, were covered by concave iron plates moulded from the unmarketable stock of the factory on the suggestion of Richard Reynolds, the director of the ironworks, in 1767. Cast iron plates saved the wooden structure from wear, but the wagons often derailed. John Curr laid down L-shaped iron rails instead of concave plates on the Steffield colliery’s tramway in 1767. The vertical side of the rails prevented the derailment of the wagons. The Longborough Railway was put into service in 1789, which was equipped with William Jessop’s T-shape rails of fish-bellied profile. The new track system was already rigid enough, not to need the wooden beams supporting the cast iron rails, but only wagons equipped with flanged wheels could run on the new railways. The fish-bellied profile rails were replaced by John Berkinshaw’s 4.5 in long, rolled rails fastened to cross beams from 1820 on the fast-growing railway system in England. The first Vignoles-type rails, like today’s rails, first appeared on the rail tracks in the 1830s. — Csikvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 29-34
\end{flushright}
The operation of Surrey Iron Railway provided that the railway lines were suitable for replacing the canals used for freight transportation, as it was constructed instead of a canal a it was originally planned. The large amount of water necessary for shipping jeopardised the operation of factories and mills.

The fast-growing transportation demands could hardly be satisfied by the development of new transportation systems. The feeding of dray horses, and the construction and maintenance of bigger and bigger stables consumed a big part of mining companies’ budgets. The situation was hampered further by the necessity of ensuring of horses for the army fighting in Napoleon wars, at the beginning of 1800s. Studying the operation of Thomas Newcomen’s steam engines, more and more inventors dealt with the idea of contracting steam powered road and railway vehicles from the second half of 18th century, but only George Stephenson could build up as good reputation, like James Watt, among the early locomotive builders. His fame was supported by the recognition that the steam traction of railways required different track like the horse tramways following the roads climbing up and running down from the hills with high gradients and sharp curves.

25 The first steam wagon was built according to the plans of the French Nicolas-Joseph Cugnot, – following in Denis Papin’s footsteps - in 1771. The wagon, constructed for the traction of heavy guns, could not be tested, because the Ministry of War withdrew the subvention from the talented artillery officer. William Murdock made successful experiments with the model of road steam locomotives in England. He recognised that James Watt’s steam engine operating at a little above atmospheric pressure was not suitable for driving the carriages, because of its large dimensions. Murdock constructed a small dimension boiler generating high pressure steam for driving the model. James Watt noticed a patent in 1784 and hindered the other inventors from constructing a road steam locomotive for 10 years, because his wagon was never built. So, Murdock had to abandon his experiments. His neighbour, Richard Trevithick continued Murdock’s experiments in Cornwall, in 1794. He put into service his first carriage in 1801. In his patent, noticed in the following year, he recorded already, that he wanted to use his steam locomotive on the horse tramways, as well. After the successful introduction of his steam carriage in London, in 1803, he built a steam locomotive, which ran for the first time on the 14 km long railway of Pen-y-Darran Iron works on 6th February 1804. Trevithick used high pressure boilers, 100psi, on his Cornish pumping engines and his locomotive Pen-y-Darren in 1800-1804. When James Watt heard this, he said that Trevithick should be hung for endangering the public. The successful introduction of the locomotive was hindered by breaking of rails, which characterised the operation of the unusually heavy steam engine. He introduced his steam locomotive called “Catch me who can” running in a 54 m diameter circle track reaching a 30 km/h speed London in 1808, but its success did not make enough money to continue the experiments. William Hedley, the chief engineer of Wylam Colliery, put into service his locomotive called “Puffing Billy” for a third trial with the help of Timothy Hackworth, which was the first steam locomotive designed for railway operation. It was used until 1862. — Csíkvári Jákó: A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian), 1883, reprint kiadás, p. 54-62

26 While William Hedley and Timothy Hackworth were engaged with the construction of “Puffing Billy” at Wylam colliery, George Stephenson, invented many innovations in Killingworth colliery, as a mining engineer. He put into service machinery for the mining of coal and built a horse tramway for the transportation of mining products. The keeping of horses took a lot of money and their feeding caused a lot of troubles during the time of the Napoleon wars, so the talented inventor turned his attention to mechanical traction. Having studied the construction of the locomotives already in operation, he built his first built steam locomotive, - the “Travelling Engine” as he called - in 1813-1814. John Thirwall, one of the smiths working for the colliery, helped him. After a long process of reparation and modification his first locomotive called “Blucher” was introduced on the Killingworth Colliery Railway, hauling eight wagons of 30 t loads on 1:45 slope to four English Miles in an hour, on 25. July 1814. George Stephenson applied coupling rods and cranks to the driving the wheels instead of difficult cog wheel transmission and rodding. After his successful activity in Killingworth colliery he was asked to solve the transportation problems of the Hutton collieries. He paid special attention to the construction of the Hutton colliery railway network so that the track and the slopes would be suitable for steam traction. He used Berkinside type rolled rails instead of cast iron. The traffic began on the Hutton Colliery Railway with six steam locomotives on 18. November 1822. The successful activity of George Stephenson attracted the attention of the inventors. They Stephensons founded the first locomotive factory in the world with Edward Pese on 23 June 1823. The director of the locomotive factory was George Stephenson’s 20 years old son, Robert. — Csíkvári Jákó: A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian), 1883, reprint kiadás, p. 63-67
The fulfilment of fast growing water and land transportation demands: the construction of rail tracks which could carry heavy locomotives without breaking the rails, bridges crossing the rivers and valleys, steam engines and railway rolling stock, required reliable raw materials, good machinable rolled steel plates, rails and profiles, first. The mass production of these materials changed the heavy industry basically in a few decades in the middle of 19th century.27  28

2.1 The Place and the Role of Narrow-gauge Railways in National Railway Networks

The first short railway lines or small networks were operated by horse traction. Only the gauges of mining railways were determined by the dimension of small wagons moved by horses or the miners themselves under the earth galleries. When the gauge was good for horse traction, it could be used also on the surface.29 However, for practical reasons, the railways built for the transport on the surface had different gauges offering higher transportation capacity.

The first steam operated Stockton & Darlington Railway was opened for public service with ceremony on 27th of September 1825. The 40 km long railway was built for transportation of coal extracted from the collieries in the environs of Shildon in County Durham to the port of Stockton-on-Tees. George Stephenson was asked to construct the railway line and the steam locomotives necessary for hauling the trains. He chose 4 feet 8 Inches (1422 mm) track gauge having used similar gauges already on Shildon colliery lines. So, the few hundred „chaldron wagons” with 1,164 m³ loading capacity carrying the coal of Shildon collieries, could run after minor modifications without restrictions on the new line built between Stockton and Darlington. George Stephenson increased this gauge by ½ inch constructing the Liverpool & Manchester Railway five years later.30

The successful introduction of steam locomotives made possible the increase in the speed of the trains running on the railways, as well as replacing the expensive and labour-intensive horse traction. George Stephenson’s Rainhill winning locomotive „Rocket” ran at a speed of 30 miles per hour - nearly 50 km/h – on the Liverpool & Manchester Railway. Increasing speed brought up the new problem of running stability, the solution of which had a close connection with the choice of gauge at that time. The railways, built with narrower gauge and cheaper investment cost, did not make it possible to increase the speed of the rolling stock, because of the problem of running safety. The running stability of rolling stock on broader gauge lines was better and could carry loads of larger dimensions. The specific steam consumption of locomotives was

27 The old manually operated workshops were soon closed, and new iron factories and rolling mills were set up close to the coal fields, manufacturing good quality steel mass products. The bloomeries, operated by water wheels, disappeared slowly in the second half of the 19th century, in which the pig iron, produced by ironworks working on the iron ore fields, was manufactured. The new blast furnaces took over the tasks of small iron works. The Siemens-Martin and Bessemer-Thomas steel production processes were introduced in the 1870s. — A Diósgyőri Magyar Királyi Vas és Acélgyár története (The History of Royal Hungarian Iron and Steel Factory, Diósgyőr – in Hungarian). 1765-1910, 1910, p. 3-4.


29 The gauge of rails varying between 600 and 800 mm, was good for below ground and for surface transportation drawn by horses. In this case the loaded wagons could run to the river loading points or to the factories directly without reloading.

30 Csíkvári Jákó: A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian), 1883, reprint kiadás, p. 77
also better, because of smaller rolling resistance of the wagons. The English engineer, Isambard Kingdom Brunel investigated the ideal gauge of railways; the result of his studies was the construction of the Great Western Railway’s 7 Feet ¼ Inches (2140 mm) gauge network in England, between 1839 and 1846.\textsuperscript{31} He revolutionized the public transportation and the science of engineering, with his numerous inventions. His activity was not always successful, but he had an important influence on the development of means of communication with the details of his inventions. \textbf{Brunel was a systematic researcher and analytical engineer of his age unlike the great characters of the industrial revolution whose activity was characterised by practical talent, practice and was helped by stroke of luck.}\ For example: Denis Papin, French physicist, mathematician and inventor, graduated with a medical degree discovered the capability of vacuum, when he forgot of his pot in which he warmed up his supper. James Watt, the Scottish instrument maker and inventor, who modified a Newcomen engine by adding a separate condenser to make it unnecessary to heat and cool the cylinder with each stroke, discovered that the piston of the vacuum steam engine had two sides, when a steam pipe was broken. George Stephenson was also practical talent.

The steam railway was an independent system of transportation at the beginning of 19\textsuperscript{th} century. Steam locomotives used for hauling the trains running on rail tracks represented only the spectacular part of it, because the tracks, bridges, tunnels, buildings and different facilities were as important for the operation of railways as the rolling stock at least. \textbf{The first successful locomotive builders were also civil engineers designing tracks and constructing railway bridges.}\textsuperscript{32}

However, spectacular success was very important in the case of the new inventions’ introduction and general use of technical products. George Stephenson and his son Robert got more and more and more important orders for constructing new railways in England and even on the Continent, after the successful introduction of their steam locomotive „Rocket”. Their activity contributed significantly the fast expansion of the 1435 mm gauge railways forcing the Members of British Parliament to accept it as a standard.

By the influence of British Parliament’s decision passed in 1846, 50 \% of the world’s railway network is standard gauge today. This network is growing, because the new high speed lines in the countries operating narrow or broad gauge national networks, like Japan or Spain, have been constructed with standard gauge. The Berlin—Moscow high speed line is designed with standard gauge.

The success of steam railways overcame soon the resistance opposed against them, and the rulers, governments and parliaments of different countries forced the construction of national networks by laws and orders, having recognised their commercial, economic, political, strategic and cultural importance.\textsuperscript{33}

\textbf{The steam operated Stockton & Darlington and Liverpool & Manchester Railways were successful enterprises already, which aroused the interest of financiers. New plans were made for the construction of steam railways instead of the roads, canals and horse tramways, proposed earlier.}\ The network of public steam railways exceeded the length of the industrial railway lines many times by the middle of 19th century. The national railway networks


\textsuperscript{32} Csíkvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, 63-89.

\textsuperscript{33} Csíkvári Jákó: \textit{A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian)}, 1883, reprint kiadás, p. 89-94.
were constructed with standard or broad gauge according to the principle of standardised gauge railway systems.

The so-called local railways got more and more important besides the national mainlines built for the long distance natural trading routes which generated great incomes. Local railways connected the distant country sides to the national networks, increasing the traffic of the main lines and transporting local goods. The investments costs of local railways' construction were hardly ever recouped because of the low incomes generated by the local transportation. Governments and parliaments tried to remove the obstacles to the construction of national railway networks. They made different concessions by undertaking the construction costs or the interest charges or guaranteeing the profit, in the case of railway enterprises from which low incomes could be expected. This led to the relaxing of the technical requirements for the local railways compared to the main lines. An actual movement was launched for constructing so called cheap railway lines of light superstructure in the 1860s, but because the lack of proper traction units it could not show practical results.

The railway lines or small networks, at first operated separately from each other, were connected to make an independent land transportation system. The national railway networks had already been established in the 1860s, while the construction of new railway lines was continued rapidly. The railway network of the Continent was created by connecting to each other the national networks in the two decades after 1860, while a special division of labour came into existence between railway lines built for different purposes, according their duties.

The Verein der Deutschen Eisenbahnverwaltungen – Union of German Railway Directorates, which determined the development of Central-east European railways through many decades, set up a four-class system to categorise the railways according to their duties fulfilled in the national systems. National main lines belonged to the first class. Local railways built with the same gauge as the main lines represented the second class. Narrow-gauge local railways offering the same level of service, comfort and speed of journey as the standard gauge local lines formed the third class. Industrial railways belonged to the fourth class which were not opened for public transportation.

The industrial railways, constructed to transport mining products, ran on the surface to slope downwards from the mines to the loading points utilising gravity. So the power of horses was necessary to haul the empty wagons only uphill. Loaded trains running towards the loading

34 The French Parliament made already a decision by 1842 to connect all the settlements of more than 1500 inhabitants to the national railway network by 1000 mm gauge local railways. The construction of uneconomical local lines did not happen until the 1870s, because of the resistance of the investors. In the beginning of the connections for the secondary railways were of lighter construction of buildings, operating and comfort facilities compared to the main lines. The development of infrastructure and rolling stock resulted in the categorisation of locomotives into main line, local and industrial railway classes. — Csinkvári Jákö: A közlekedési eszközök története 2 kötet (The History of Means of Transportation part 2 - in Hungarian), 1883, reprint kiadás, p. 198-210.

35 Landau Gusztáv és Walter Ágost: Az európai fontosabb helyiérdekű rendes és keskenyvágányú vasutak leírása egy javaslattal a magyarországi helyi érdekű vasutak építésénél és üzleténél követendő elvekre nézve (Description of Important Narrow and Standard Gauge Railways with Proposal for Exemplary Principles for construction and operation of Hungarian Local Railways – in Hungarian), A közmunka és Közlekedés Magyar Királyi Ministerium kiadmányai, Tizenharmadik füzet, Budapest, 1878, p. 187-188.

36 ib

37 The gravity railway was a typical solution for the construction of narrow gauge lines transporting goods. Utilising the force of gravity decreased significantly the cost of transportation. It was frequently used in forest and quarry railways, too. — Bodányi Ödön: A keskenyvágányú vasutak nemzetgazdasági jelentőséges ezzel kapcsolatban a mezőgazdasági iparvasút és a Neufeld Károly-féle körösi völgyi erdőüzlet gurahonci erdei vasúttá III. rész (The Importance of Narrow Gauge Railways in the National Economy and the
points also carried the horses on wagons, shortening the journey time. The first trials, for the introduction of steam traction on the narrow-gauge lines, were made in the 1850s, but because of the inadequacy of steam locomotives these trials failed. An 11 km long, 1106 mm gauge steam operated colliery railway was constructed in Austria in 1854. The gauge was the same as the Gmunden—Linz—Budweis horse tramway constructed between 1827 and 1836. The steam traction was introduced on Linz—Gmunden line section in 1855-56. Although the line section was converted to standard gauge only in 1903, the rolling stock running there did not make an exemplary model for the construction of narrow-gauge vehicles. The general introduction of steam tractions had to wait for many decades after the success of Liverpool & Manchester Railway. Putting into service of steam locomotives on the 597 mm gauge Ffestiniog Railway in Wales brought the breakthrough in 1863. After the success of the Ffestiniog Railway the narrow-gauge railways became a rival to standard and broad gauge lines regarding the technical solutions and transportation capacity, especially in the areas where the capital invested in the construction of standard and broad gauge lines would have never been returned, because of the low transportation demands. **At that time the standard or broad gauge national networks were extended to the local areas in the well developed countries of Europe and the World according to the principle of standardised gauge railway systems. The wider use of narrow-gauge public railways was only possible in the colonies, underdeveloped countries and countryside.**

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**Mezőhegyes Farm Railway and Gurahonc Forest Railway in Kőros Valley Forest Industry of Neufeld Károly part 3 – in Hungarian), Magyar Mérnök- és Építészegylet Közlönye, 26/12 (1892) p. 393-399.**

38 Landau Gusztáv és Walter Ágost: *Az európai fontosabb helyiérdekű rendes és keskenynyomú vasutak leírása egy javaslattal a magyarországi helyi érdekű vasutak építésénél és üzleténél követendő elvekre nézve (Description of Important Narrow and Standard Gauge Railways with Proposal for Examplary Principles for construction and operation of Hungarian Local Railways – in Hungarian), A közmunka és Közlekedés Magyar Királyi Ministerium kiadmányai, Tizenharmadik füzet, Budapest, 1878,**

39 The Railway, opened in 1836, could not ensure anymore the empty wagons for the quarries by horse traction. The development of the steam locomotives made it possible to build smaller and smaller powerful steam engines at that time, notwithstanding that famous locomotive builders, like Robert Stephenson declared that “Steam locomotives with economical operation could be never built for so narrow gauge”. The steam locomotives, put into service in 1863, increased the transportation capacity of the 20 km long railway that carried slate, worked out from the quarries around the mining town of Blaenau Ffestiniog, to the port of Porthmadog. In 1865, passenger service, run by steam locomotives, was introduced. Putting into service of the Fairlie type steam engines in 1870 made it unnecessary to build double track on the line. — Preyer Győző: *A keskenynyomú vasutak legésszerűbb vágányzata (The Most Rational Track of Narrow Gauge Railways – in Hungarian),* Budapest, Vasúti és Közlekedési Közlöny 145/1888, p. 1381-1382., 148/1888, p. 1403-1404., 151/1888, p. 1423-1424., 154/1888, p. 1450-1451.
2.2 The Construction of the Four Level Railway Network and the Introduction of Steam Operated Narrow-gauge Railways in Hungary

The wooden plate ways were used also in the Hungarian mines in the 18th century. Mária Terézia queen of Hungary imported miners from Thuringia to the Transylvanian goldmines of Brád, which were worked also by the Romans. The Thuringian miners had the knowledge of constructing and using of the underground transportation system. She made an order to search for industrial raw materials and coalfields of good quality coal, which can be utilised in the new iron making processes. Her order started the working of Dorog and Resica coalfields and the iron production in Resica and its surroundings. The first steam engine already appeared in Hungary in the 18th century. In 1722 Isaac Potter, the English inventor put into service a steam piston to rise the water from the gold mines of Újbánya in Bars County. On the basis of good practice gained by the steam engine, the Royal Chamber in Vienna decided to put into service another five steam engines in Selmec mining area to replace the 500 horses used for driving of water pumps. Kempelen Farkas, the Hungarian polyhistor of that age, met with James Watt in England on his long journeys. He also constructed a working steam engine but his technical talent was engaged by construction of fountains of the Schönbrunn Palace in Wien, and the canalisation system in Buda castle and in the city of Pozsony.

Nearly ten years passed after the Palmer type suspended railway was unsuccessful introduced in Hungary in 1827, when the Hungarian Parliament put into force the support of construction of the national railway and canal networks to develop the trade of the country by passing the act XXV of 1836. 13 main routes were determined, of six ran from the city of Pest to the borders of the country. Six years after that the first section of Pozsony—Nagyszombat public horse tramway were put into service on 27. September 1840, the first steam railway was opened ceremoniously between Pest and Vác on 15 June 1846. The Hungarian Parliament - on his section in the city of Pozsony - made a decision to support the construction of six railway lines, first of all to the port of Fiume - instead of the construction of Wien Triest Railway’s sections running on the Hungarian territory - by 10 million Forints, on the proposal of count Széchenyi István on 7. April 1848.

The erosion of the revolution and the defeated liberation war of 1848-49 slowed down significantly the industrialisation and economic development processes just started the age of reforms between 1825 and 1848. In 1867 the year of Compromise, four railway companies operated a little more than 2200 km long steam railway network in the countries of the Hungarian Holy Crown. The Pozsony Nagyszombat Tramway, opened for public the whole line in 1846, and a number of industrial railways, constructed for the transportation of mining products, were operated by horses alongside the first-class steam railways. A colliery railway network was constructed in Karu Coal Mines near Özd in 1855. The nearly three km long railway was opened between the collieries and the iron factory of Rimamurányvölgyi Vasmű Egyesület in Özd, in 1861. A 700 mm gauge tramway carried the coal between Domán and Resicabánya in 1864. Remarkable horse operated industrial and mine railways were operated in Selmecbánya.

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40 Mårten Triewald, A Short Description of the Fire- and Air- Machine at the Dannemora Mines, Stockholm, 1734 Egyetemi könyvtár, Rochester


42 1848 évi XX. Törvényeik a felelős ministerségnek a közlekedési tárgyak iránti teendőiről (Act XXX. of 1848 for the duties of the responsible Ministry in connection with the objects of transportation – in Hungarian), Országgyűlési Könyvtár, Budapest
After that the constitutional government came into power on 20. February 1867, the elimination of backwardness of the many decades which hindered the economic development in the countries of Hungarian Holy Crown started. As the general and proportionate sharing of taxation had been introduced, the development of the transportation conditions – among others of the railway system – became an important part of the legislation activity employed for boosting up the industry and trade. Maintaining the earlier supporting system, the Hungarian State guaranteed and paid the missing amount of the costs for the Private Railway Companies even if the operation of their new lines was not profitable and the incomes were less, than it was calculated earlier. Having bought the Budapest—Hatvan—Salgótarján line from the Magyar Északi Vasút company that went into bankruptcy, the Hungarian State participated directly in the development of the national railway system from 1868 and established - the Royal Hungarian State Railways - MÁV Company. The Hungarian State took upon itself the construction or the support of the construction with heavy expenditures of railway lines which seemed to be doubtful enterprises for the private interests but were important from the point of view trading and of strategy. Alongside the first-class main lines the Miskolc—Bánrévé line served the transportation demands of Gömör and the fast developing Borsod industrial areas. It was constructed according to second class railway standards and became the model for the construction of first secondary lines built in the 1870s. The lines of the Gömör Industrial Railways, Miskolc—Diósgyőr, Valkány—Perjamos, Vojtek—Németbogsán and Nyíregyháza—Ungvár railways were built on the basis of technical specifications applied as standards at the construction of Miskolc—Bánrévé line.

The search for and the fast growing exploitation of natural resources, foundation of new factories of higher and higher production capacity required new transportation lines. The fast development of narrow-gauge network started alongside the construction of national main lines by the influence of industrial development after the Compromise of 1867. In the forthcoming year of the Compromise the Brennbergi Szénbányatársulat (Brennberg Colliery Company) built a 790 mm gauge horse tramway on the surface between the shafts worked in the hills of Sopron and Ágfalva railway station of Déli Vasút (Southern Railways). A metre gauge colliery railway was built between the State Iron Factory of Diósgyőr and coal mines of Pereces which

46 The Act XLIX. of 1868. provided to place into service the Pest—Hatvan—Salgótarján railway line taken over by the State Treasury. Furthermore, the construction of the Hatvan—Miskolc, Zákány—Zágráb, Károlyvárös—Fiume, Salgótarján—Ruttka, Hatvan—Szolnok and Miskolc—Putnak railway lines, it provided to cover one third of the expenses of the construction of the line connected to the last one and running to the mining areas of the iron industry and the Nyíregyháza—Ungvár line which was important in the transportation of timber from the Carpathian Mountains. — Országgyűlési Könyvtár, Budapest
48 Because of the big difference in level, the up and down section of the 790 mm gauge colliery railway, opened in 1868 was connected to each other by a funicular railway. In 1875, the steam traction was introduced and in 1893 the Ágfalva—Brennbergbánya section of the colliery railway was abandoned. A new standard gauge industrial
provided good quality coal for the refining of iron, in 1869. Because of the small difference of level the traction horses was necessary for hauling the loaded wagons towards the factory. The continuous production of furnaces and rolling mills required more coal than the horses could transported.49 The management of Diósgyőr State Iron Factory decided to put into service steam locomotives after opening the colliery line to avoid the difficulties of coal transportation. The first locomotives of Pereces Colliery Railway arrived at Miskolc Gömöri station in December of 1870.50 The coal transportation with horse traction began on the 12.3 km long, 948 mm gauge colliery line from Szekul Coal mine in the fourth quarter of 1870. The tramway was built by the Resica Iron Factory of ÁVT 51 on its own budget. The Resica—Szekul tramway was soon rebuilt for steam traction and the transportation of raw material for the furnaces and iron works started again in June 1871, after that the steam tank locomotive called “Szekul” had arrived. It was built with 0-4-0 wheel arrangement in the Machine Factory of Bécs—Győr (Wien—Raab) Railway and designed by John Haswell.52,53 Meanwhile the coal production of the domestic mines doubled in five years after 1867, the new colliery horse tramways reached the limit of their transportation capacity very soon and steam traction was introduced on their busiest lines.54

In November 1871, the factory of the Salgótarjáni Vasfinomító Társulat (Salgótarján Iron Finery Company) was opened, and the regular transportation of coal began on the 790 mm gauge colliery line built between the factory and the near-by Salgó mine-head. In the same year, the Salgótarjáni Köszénbányatársulat (Salgótarján Coal Mine Company) began to build the colliery line to connect its shafts with the Zagyva railway loading point. Two steam locomotives of 45 HP (33.1 kW) were put into service to haul the trains on the 8 km long, 790 mm gauge siding was built from Ágfalva station directly to the new mines. The new line was 8 km long and had a steepest slope of 28.4 % — Mezei István szerkesztőMagyar vasút a XIX. Században (The Hungarian Railway in the 19th Century — in Hungarian), 2009. Budapest, MÁV Vezérigazgatóság

49 A Diósgyőri Magyar Királyi Vas és Acélgyár története (The History of Royal Hungarian Iron and Steel Factory, Diósgyőr — in Hungarian). 1765–1910, 1910, p. 3.

50 Borsod Miskolci Értesítő, IV. évfolyam, 47. szám, 1870. november 24. Országos Széchenyi Könyvtár, Budapest

51 k. k. privilegierte österreichische Staatsisenbahn-Gesellschaft (Imperial and Royal Privileged Austrian State Railway Company - STEG), Császári és Királyi Szabadalmazott Államvaspálya Társulat (Imperial and Royal Privileged State Railway Company - ÁVT) between 1867 and 1882, Szabadalmazott Osztrák-Magyar Államvasúttársaság (Privileged Austro-Hungarian State Railway Company - OMÁV) from 1882. The Company was funded with French private capital and took over the network of Eszaki (Northern) and Dél-keleti Államvasútak (South-East State Railways) from the Austrian State, in 1855. The Company operated 1350 km long railway network in Austria, and 1500 km in Hungary in 1890. The Company had a locomotive fabric in Wien, Iron factory, steel plant and a machine factory producing railway equipment in Resica. The Hungarian State took over the Company’s Hungarian network and plants in 1892. — Dr. Kovács László főszerkesztő: Magyar Vasútérténet a kezdetektől 1875-ig (The History of the Hungarian Railways from the Beginning to 1875 — in Hungarian), Budapest, MÁV Rt. 1995; — Dr. Kovács László főszerkesztő: Magyar Vasútérténet 1876-tól a századfordulóig (The History of the Hungarian Railways from 1876 to the Turn of the Century — in Hungarian), Budapest, MÁV Rt. 1996.

52 The wheel arrangement is one of the most important technical characteristic of the railway rolling stock especially the tractive stock including the steam locomotives. The wheel arrangements applied most frequently on the narrow-gauge steam locomotives contain the Table 1.3 of Annex 1. — UIC Leaflet 650 Standard designation of axle arrangement on locomotives and multiple-unit sets, 5th edition of 1.1.83, International Union of Railways.


54 In the next five years following the Compromise of 1867, the length of the Hungarian national railway network nearly tripled, and the steam locomotive stock doubled. The number of steam engines, which were used in the industrial production, was increased by nearly two and half times. Meanwhile the domestic rude iron production was increased by 50 percent, the steel production doubled. — Képviselőházi irományok, 1875. XIV. kötet 502-558. sz 1875-558. Törvénymavaslat, a magyar korona országai és ő Felsége többi királyságai és országai között kötött vánum- és kereskedelmi szövetségről (1875-XIV-339. oldal), Országgyűlési Könyvtár, Budapest
railway, constructed in 1871-72. The Hungarian Parliament passed the Act XII of 1872 for to construct the Miskolc—Diósgyőr secondary line and the 750 mm gauge fourth class Máramaros-sziget—Szlatina Railway for carrying salt only, on state budget. The 10 km long, Bánréve—Ózd line section of metre gauge Bánréve—Nádasdi Industrial Railway was opened on 1. November 1872. Its construction was supported by state budget on the Act XXXII of 1870 of the Hungarian Parliament and was carried out meeting the requirements of third class railway standards. The steam locomotives purchased to handle the traffic had 0-6-0 wheel arrangement and were called „Ózd” and „Nádasd”. They arrived from Wiener Neustadt and were built by Sigl Locomotive Factory. On the 10th of August 1873, the third-class metre gauge steam operated local railway was opened for public service first, in Hungary between Garamberzence and Selmecbánya. In the same year the ore transportation began on the metre gauge Bindt Valley Industrial Railway of archduke Albrecht.

Characterizing the speed of the industrial development in Hungary after the Compromise of 1867, the new narrow-gauge industrial railways, which were built for horse traction after 1867, reached the limit of their transportation capacity in one or two years of operation. Steam locomotives were put into service on their lines, and the railways which were planned and under construction for horse traction had to be converted to steam operation. (Thesis I.)

See the technical data of first narrow-gauge steam locomotives put into service in Hungary in Annex 1.

56 In 1873, the 1.85 km long standard gauge line was completed only which connected the treasury salt-depot with Máramaros-sziget station of Magyar Északkeleti Vasút (Hungarian North East Railway). The 4.5 km long line, running from the salt-depot of Máramaros-sziget to the Kunigunda shaft in the fields of Szlatina village, was put into service on 5 June 1880. — Vörös László szerkesztő: Magyar Vasúti Évkönyv I-VI (Yearbook of Hungarian Railways – in Hungarian), 1878-1883, Budapest
57 1870. évi XXXII. törvénycikk a bánréve-nádasdi gőzmozdonyú iparvasút kiépítése tárgyában (Act XXXII of 1870 for the construction of Bánréve—Nádasd Steam Locomotive Railway – in Hungarian), Országgyűlési Könyvtár, Budapest
58 The railway was designed originally to transport the materials utilised by the Selmec Mining Works, first to carry coal as a horse tramway. Since the postal service was the lonely possibility for travelling to Selmebánya at that time the MAV took over the direction of constructing works and put into operation the railway with steam traction and opened for passenger traffic. — Herczog Ödön: A selmeci keskenyvágányú bányavasút (Narrow Gauge Mine Railway of Selme – in Hungarian), Magyar Mérnök- és Építészegylet Közlönye, 7/4 (1873), p. 138-145.
3 Narrow-gauge Steam Locomotive Production in Hungary

3.1 From the Beginnings to 1905

3.1.1 Industrial Railway – Narrow-gauge Local Railway. The Development of the Narrow-Gauge Railway Network in Hungary, after the Compromise of 1867 until 1905.

Due to the influence of the industrial development succeeded the Compromise of 1867, by 1883 twenty narrow-gauge steam railways were operated with total length of 303 km in Hungary, alongside the standard gauge network that exceeded 7200 km. Some of the narrow-gauge railways were opened for public service; the others transported only mining, agricultural and forest products excluded the public as private railways. More than two-third of the network was built with 948 and 1000 mm gauges. The length of the 750 mm gauge lines exceeded 60 km. The extension of the 790 and 800 mm gauge lines was also significant which were used on the mining areas. The narrowest gauge was 633 mm. The extension of different gauges on the narrow-gauge network reflects to the approach of that time which preferred the 1000 mm gauge lines because of their higher transportation capacity and better comfort ensured by the larger loading gauge. The 5 km long 790 mm gauge rack railway was also in service among the industrial railways at that time which connected the factory of the Salgótarjáni Vasfinomító Társulat (Salgótarján Iron Finery Company) and the near-by Salgó mine-head, worked by the company.

Apparently, there was not any restriction in choosing the gauges of the first narrow-gauge lines built in Hungary, but for the gauges of railways, the construction of which was supported by the Hungarian State, less than 1000 or 750 mm were not allowed to use, as accepted by the Parliament, and preferred by the Union of German Railway Directorates.

61 62 63

60 Although, the technical literature uses only the English units of measurements. This is acceptable only in case of railway gauges originated from the United Kingdom. The local units of measurements as well, applied before the invention of metric system, should also take into consideration. The 750 and 1000 mm gauges are connected to the metric system. Taking into consideration of the Vienna foot used in Austria and in Hungary

1 Vienna foot = 0.31608 m,

the gauge of 633 mm railways takes two, the gauge of 790 mm takes two and half, and the 948 mm takes three measured in Vienna foot. Originally the gauge of the Resica—Szekul Railway was 948 mm, which was changed officially 950 mm after the invention of the metric system. — Ulrich Antal, A Resica-Szekull keskenyvágányú vasút leírása (The Description of Resica—Szekul Narrow Gauge Railway – in Hungarian), Magyar Mérnök-és Építészegylet Közlönye 9/11 (1875), p. 466-474. — 1874, évi VIII. törvénycekk a métermérték behozataláról (Act VIII of 1874 for the Invention of Metric System – in Hungarian), Országgyűlési Könyvtár, Budapest

61 Csikvári Jákó: A közlekedési eszközök története 1 kötet (The History of Means of Transportation part 1 - in Hungarian), 1883, reprint kiadás, p. 96.

62 1870. évi XXXII. törvénycekk a bánréve-nádasdi gőzmozdonyú iparvasút kiépítése tárgyában (Act XXXII of 1870 for the construction of Bánrévé—Nádasd Steam Locomotive Railway – in Hungarian), Országgyűlési Könyvtár, Budapest

63 The Act X of 1872 on the extension of the network of the Gömör Industrial Railways authorised the construction of the Tiszolc—Rhönici and Tiszolc—Vashegyi Industrial Railways at least with 750 mm gauge. The planned, nearly four km long Tiszolc—Vashegy line would have connected the Ferenc József shaft and the neighbouring László adit with the Tiszolc railway station of MÁV. The planned smallest radius was 40 m, and the steepest gradient was 27 % on the line. Another station at Nagyőrőc, and a 215 m long tunnel were also planned between the sections 312 and 315, besides the shaft stations. — A tiszolc vashegyi vonal tervezéi (The plans of Tiszolc Vashegy line – in Hungarian), MÁV Zrt. Központi Irattár 178/H; A Tiszolc Vashegyi vonal hosszlevénye (The longitudinal section of Tiszolc Vashegy line – in Hungarian), MÁV Zrt. Központi Irattár 178/H2
In the autumn of 1878 the construction works of the Bród—Zenica Military Railway began to support the operations and to ensure the reserves of the Austro-Hungarian troops occupying Bosnia-Herzegovina by the Congress of Berlin’s decision. The rolling stock and the tracks of the 760 mm gauge railway were utilised which were used for the earthworks at constructing the standard gauge Temesvár—Orsova line before. The construction works were getting on fast. More than the 100 km long section of the line was serviceable in the spring of 1879 and the railway constructing troops laying down the tracks arrived soon at Zenica. The railway was designed for the transport of foods and munitions by horse traction originally, but because of the long-extended fighting, the railway became more and more important in the transportation of reserves and the armaments and equipment necessary for the preparation of military operations. The loading gauge of the railway, the low capacity of steam locomotives and the small wagons put into service on the line made not possible the transportation of the necessary heavy military equipment and road wagons loaded with foods and munitions, because of their large dimensions. The construction of the railway was continued with 760 mm gauge via Sarajevo against the unsuccess, but the track infrastructure was constructed so, that the standard gauge rails could lay down easily without reconstructions, as provided by the Act I of 1881 of the Hungarian Parliament. At the same time the loading gauge of the metre gauge lines was introduced. The introduction of larger loading gauge combined successfully the advantageous features of the two different narrow-gauge lines. It made possible the introduction of public service on the 760 mm gauge lines. The decreasing of 1000 mm gauge to 760 mm made cheaper the construction of the railways significantly compared to the metre gauge railways.

64 The Congress was convened on the initiative of Bismarck, in 1878. The aim of it was to organize the affairs of Balkan after the Russian Turkish war, and to change the provisions of San Stefano Peace which ensured the Russian influence on the Balkan. The Congress authorized the Austro-Hungarian Monarchy to occupy and to govern the Bosnia-Herzegovina Turkish provinces on the proposal of England.

65 Taking into consideration the running stability as the basic problem, the railway constructors of the age accepted the practice of the standard gauge railways in the lack of proper experiences and used fixed ratio relative to the gauges to determine the width of the narrow gauge rolling stock. This ratio of stability was dependent of the speed. The difference between the speeds of the trains running on the public standard and narrow-gauge lines was not so significant at that time. Therefore, the similar ratio of stability: 2.4-2.6 was used for the narrow gauge rolling stock as the standard gauge. In this case the narrowest gauge of the rolling stock that offered still comfort was about 1000 mm. This value was increased up to 3.2 in case of the Bosna Railway. (See Fig. 1.)

66 The 750-760 mm gauge railways were built with a loading gauge of 1800 mm width before the 1880s. This made not possible to build wagons for public service meeting the minimum requirement of comfort and transportation of goods and the necessary powerful steam locomotives, but the 2500 mm wide loading gauge of 1000 mm gauge railways was good regarding as the commercial and as the technical aspects. — Preyer Gyöző, A keskenyomú vasutak legésszerűbb vágányzata vágányzata (The Most Rational Track of Narrow Gauge Railways – in Hungarian), Budapest, Vasúti és Közlekedési Közlöny 145/1888, p. 1381-1382., 148/1888, p. 1403-1404., 151/1888, p. 1423-1424., 154/1888, p. 1450-1451.
The management of the Boszna Vasút (Boszna Railway) turned to the locomotive manufacturers in order to purchase the steam engines most convenient for the transportation requirements. The introduction of larger loading gauge made possible the procurement and running of rolling stock of larger dimensions and higher capacity.

The introduction of larger loading and rolling stock construction gauge made unnecessary to convert the 760 mm gauge of the Bród—Szarajevó line to standard gauge.

The network was enlarged and by the end of the century reached the port of the Dalmatian Sea. The development of the rolling stock running on the network was continued. From 1886 more and more powerful steam engines of Klose system were put into service to negotiate

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67 The A, B and C gauges according to the § 42 of basic principles for the construction of second class railways.

68 Answering the announcement, the Krauss Locomotive Factory of Munich made a bid for the delivery of steam locomotives with the wheel arrangement 0-4-0 and of 80 HP (58.9 kW) effective power output, coupled to each other at the driver’s cabs. The regulator handles, and the valve gears of the locomotives were coupled to each other by rodding, so only one engine driver and a fire man were necessary to operate a twilling locomotive, like the Fairly type steam engines. Despite the Fairly type steam engines the locomotives were able to operate separately. — Preyer Győző, A keskennyomú vasutak legésszerűbb vágányzata vágányzata (The Most Rational Track of Narrow Gauge Railways – in Hungarian), Budapest, Vasúti és Közlekedési Közlöny 145/1888, p. 1381-1382, 148/1888, p. 1403-1404, 151/1888, p. 1423-1424., 154/1888, p. 1450-1451.


the small radius curves, running by 50 km/h speed on the Bród—Sarajevo line besides the twilling locomotives built by Krauss Locomotive Factory in Munich.  

Freight wagons of longer and longer wheel base and heavier loading capacity were put into service abandoned the principles of rolling stock construction at that time. The freight wagons of 10 t loading capacity were able to carry the full load of standard gauge wagons.

After the success of the Boszna Railway, the third class 760 mm gauge railways were accepted as public railways in the national railway transport system. The Budapest—Pestszentlőrinc and Taracköz—Nyéresháza Local Railways were put into service as the first 760-gauge public railways in Hungary, in 1887. Meanwhile, the network of the industrial railways was also extended, the steam railways carrying the products of large estates also appeared, besides horse tramways built for the transportation of raw material to the sugar-factories.  

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71 The Klose type radial steam engines appeared soon on the Boszna Railway, besides the twilling locomotives. Julius Kraft, the technical director of Boszna Railway supported to put into service the locomotives based on the good experiences gained by the passenger coaches and freight wagons equipped with Klose curve negotiating system. — Preyer Győző, A keskenynyomú vasutak legésszerűbb vágányzata vágányzata (The Most Rational Track of Narrow Gauge Railways – in Hungarian), Budapest, Vasúti és Közlekedési Közlöny 145/1888, p. 1381-1382., 148/1888, p. 1403-1404., 151/1888, p. 1423-1424., 154/1888, p. 1450-1451.

72 Applying Heusinger’s theory for the Boszna Railway the rigid wheelbase of the rolling stock was 1.7 m according to $s_{\text{max}} = 0.2 \cdot e \sqrt{R_{\text{min}}}$, where - the gauge was $e = 760$ mm, and $R_{\text{min}}$ - the smallest radius of the railway - 50 m. This allowed to use only freight wagons of 2.5 m length and of 2.5 t load. The invention of Klose type curve negotiating system, and later the bogies, made possible to put into service freight wagons of larger dimensions and heavier loading capacity. — Preyer Győző, A keskenynyomú vasutak legésszerűbb vágányzata vágányzata (The Most Rational Track of Narrow Gauge Railways – in Hungarian), Budapest, Vasúti és Közlekedési Közlöny 145/1888, p. 1381-1382., 148/1888, p. 1403-1404., 151/1888, p. 1423-1424., 154/1888, p. 1450-1451.

73 Bodányi Ödön: A keskenyvágányú vasutak nemzetgazdasági jelentőséges ezzel kapcsolatban a mezőhegyesi gazdasági iparvasút és a Neufeld Károly-féle kőös völgyi erdőüzlet gurahonci erdei vasútja I-III. rész (The
railway was opened on the Hungarian Plain at the end of the nineteenth century combining the advantageous features of third and fourth class railways. The fast enlarging network of third class railways took over more and more from the transportation duties.

The last decade of nineteenth century brought important changes in the evaluation of importance of the narrow-gauge railways in the national railway system. The reductions inspiring the construction of second class railway network - the construction of local railways with smaller curve radius and lighter axle load – made more difficult the consequent application of the principle of standardised gauge national networks as suggested by the decision of the British Parliament in 1846. The fast increasing railway traffic on the main lines requested to put into service freight wagons of heavier loading capacity which could run only with restrictions on the local railways built with light superstructure for 11-12 axle load or were excluded from the secondary lines because of their long wheel base not able to negotiate the small radius of curves.

The decision of the British Parliament which declared the principle of standardised gauge national networks hindered intentionally or not intentionally the wider spread of the cheaper public narrow-gauge lines as a part of the national railway networks not only in England but also in the countries of the continent until the end of the century. Hungary was one of the leaders of the countries in constructing the local railway network in the last two decades of the nineteenth century and until the break out of the World War I.

Hieronymi Károly, who was later minister of commerce of the Hungarian Government, explained in his presentation held on the congress of technicians in September of 1902: “The total length of the Hungarian railway network should reach 27 000 km, according to the results of the calculations of Considere French Engineer – who stated that a railway did not make any economical influence on the markets farther than 12 km from the centre of its track – and taking into consideration that there should be a railway from every points of the country in 12 km distance at most and supposing that the straight lines of the railway network should divided Hungary into squares of 24 km long sides.”

The secondary, local railway lines connected the far country sides off the main lines to the economic activity of the country, transported goods and passengers towards the main lines increasing the traffic of the national network and at last but not least their construction created markets for the products of the Hungarian railway industry, strengthening by this the industrial development of the country.

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74 The agricultural railways were narrow gauge railways equipped with the fourth-class railways’ operational and safety equipment and were constructed for the transportation of agricultural products principally but opened for limited public service including the passenger service, as well. — Sármezey Endre: Mőtoros kocsik vasúti üzemben (Railcars in Railway Service – in Hungarian), Magyar Mėmők- és Építészegylet Közlőnye 3/8 (1904), p. 84-103.

75 The necessity of reloading at the connecting stations increased the transportation costs. Running of freight wagons on the main lines with limited loading capacity reduced the efficiency of the standard gauge networks significantly by decreasing the speed of the freight flow and the empty/loaded rate of the trains. The construction of secondary lines with weak superstructure left a serious heritage. Rolling stock which could run on the whole network without limitations had to be maintained until that the axle load was not increased and the small radius track curves were not reconstructed on these lines. — Zelovich Kornél: A magyar vasutak története (The History of the Hungarian Railways – in Hungarian), Különnyomat: A magyar közlekedés monografiája, Budapest, 1925.

76 Zelovich Kornél: A magyar vasutak története (The History of the Hungarian Railways – in Hungarian), Különnyomat: A magyar közlekedés monografiája, Budapest, 1925.
The guaranteed interest system forcing the construction of secondary, local railway lines in Hungary made more and more engagements for the state treasury to pay which financed the economic boom of the millennium years. Many of the new local railways, planned for standard gauge originally, was constructed with narrow-gauge from the second half of the 1890s, because of the lack of finance and the bankruptcy of the guaranteed interest system.

The consequent application of the standard gauge network principle became the obstacle of the further development of the railway system and the increasing of railway traffic by the 1890s. The solution was the further use of standard gauge wagons of short wheel base in England, and the abandoning of the principle in the countries of the continent.

The construction of four class railway network system was completed in Hungary by the end of the 1890s, as classified by the principle accepted the Union of German Railway Directorates in which: the secondary local railway lines were connected to the network of first class national main lines. This was completed by the third class narrow-gauge lines provided the same quality of service as the secondary lines and by the network of fourth class railways constructed for industrial transportation mainly built with narrow-gauge.

The narrow-gauge railway was progressed to a transportation system in the Austro-Hungarian Monarchy by the turn of the nineteenth-twentieth century which was able to provide economically the duty of industrial, local and railways and the national networks as well. Besides the short third class local railways built for the completion of the standard gauge national networks originally, the length of the narrow-gauge local railways constructed at the turn of the century reached 60-80 km. These lines and their small local networks could fulfil the transportation demands of country regions, like the secondary lines.

The length of the metre gauge local railways was already 118 km and the length of the 760 mm gauge was 461 km in Hungary, in 1900. The imposing results reached by the development of Bosnian-Herzegovinian network got the contractors to construct 760 mm gauge third class local railways in greater part. The traffic performance of the Bród—Sarajevo line exceeded transport service provided by standard gauge main lines of lower traffic volume in the

77 Because of the little incomes and the high investment costs of the oversized buildings, and installations relative to the low traffic density, the transportation on 41 local railways out of the 120, were more expensive, than on the country lanes in the countries of the Hungarian Holy Crown, in 1900. The prizes, getting higher by the influence of the economic crisis erupted suddenly at the end of the century, had broken the dynamism of the construction of secondary railways. The length of the local railway lines was 147 km opened in 1900, compared to the millennium year, when the length of the local railway lines put into service was 969 km. The situation became so serious, that the Hungarian Parliament authorised only the construction of the Kunszentmiklós—Dunapataji Local railway in 1901. — Zelovich Kornél: A magyar vasutak története (The History of the Hungarian Railways – in Hungarian), Különnymat: A magyar közlekedés monográfiája, Budapest, 1925

78 The network of the industrial railways was much longer than this; 2791 km were operated on the territory of the Hungarian Holy Crown, at the turn of the century. The development and the evolution of the network were in close connection with the appearance of the factories and the fast-growing industrial production from the second half of the nineteenth century. The fourth-class railways generally used for the transportation of industrial and agricultural products formed the most miscellaneous part of the former railway traffic system. In the absence of standardised technical requirements, these railways were built to meet the actual transportation demands taking into consideration the gauge, the axle load and the speed. The length of their lines lasted from few meters to more than 100 km. The wagons were moved by hands and horses on more than 50 % of the network besides the lines operated by steam locomotives, still at the turn of the century. The electric traction began already in 1892 by putting into service two electric locomotives in the János Shaft of Mízerfa on the Salgótarján coal mining area. The introduction of the third-class type limited public service on some lines increased the variety of the industrial network. — Zelovich Kornél, A magyar vasutak története (The History of the Hungarian Railways – in Hungarian), Különnymat: A magyar közlekedés monográfiája, Budapest, 1925
Monarchy and competed with the most important main lines regarding the mean speed of the journey. A draft bill was made for the regulation of the inferior railways’ situation in Hungary, in 1907, which contained the proposals also for the standardisation of narrow-gauge railways besides the second-class local railways. It proposed the use of 760 mm gauge as standard and the 13.75 kg/m type rails at least, but it was never presented for discussion to the Parliament. The different types of rails are characterized by their weight per length. The strength of the rails is very important in determining the axle load and speed of the trains.

The pioneer activity of Sármeczy Endre in the motorization of railways determined basically the management and the development of the rolling stock built for the railways of low traffic density, after the turn of the century. The introduction of rail car service, the separation of passenger and freight traffic made profitable also the operation of narrow-gauge farm railways built for the transportation of agricultural products basically, which were obligated to maintain passenger service. Besides the narrow-gauge local railways having already been in operation, the limited public service was introduced on some industrial railways. Some of these industrial railways were newly built the others were already in operation. After the turn of the century the MÁV did not use timber as raw material of sleepers, produced for the track construction and track maintenance works, which were swum down on the wild rivers of the Carpathians to the wood mills working at the foot of the mountains. The trustees of the forest industry were forced indirectly to build narrow-gauge industrial railways in the hope of bigger state orders.

### 3.1.2 The starting of the narrow-gauge steam locomotive production, the setting up of the Hungarian industrial background

The steam locomotives arrived from England to the first railways of the Continent. Having collected and utilised the experiences gained by the operation of rolling stock built by foreign manufacturers, new railway vehicles were built at the beginning of the 1840s, by the maintenance workshops set up nearby the railways. The few steam locomotives among them were identical with those which were put into service earlier. The absence of the industrial background producing good quality castings and raw materials made not possible the serial production of the rolling stock, but all of the obstacles were defeated which hindered the introduction of the independent locomotive manufacturing in the countries of the Continent, soon after setting up the foundries, rolling mills and machine factories of the level of the age. In the beginning workshops gained more experiences by the maintenance and reconstruction of steam engines began to build new locomotives on the instructions of experts imported from England. Also the foundries and machine factories set up originally for the manufacturing of industrial products started to build locomotives. The construction of railway lines: making of cuts and embankments, and drilling of long tunnels demanded a lot of earth works. The application of steam locomotives for moving the work trains on the tracks used for the earth transportation speeded up the work flow and reduced the construction costs significantly. Factories specialised for the manufacturing of small and light steam locomotives meeting the requirements of the operation.

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79 *Az alsóbbrendű vasutakról szóló törvény tervezete (Draft Bill for the Regulation of the Inferior Railways – in Hungarian)*, Budapest Athenueum, 1909

80 The different types of rails are characterized by their weight per length. The strength of the rails is very important in determining the axle load and speed of the trains.

81 Sármeczy Endre (1859-1939) was a mechanical engineer with university degree. He studied in Zürich. After returning home he worked for MÁV for a short period. As he joined to the Arad Csanádi Egyesült Vasutak (ACsEV) he was in charge of the construction of the Mezőhegyes—Kétegyháza line. He led the construction of the hill side Gurahonc—Brăd and the Késmárk—Szepesbélá—Podolin lines, as well. He was on of the engineers, later the head of the headquarters’ track maintenance department, and the director of the ACsEV, after the death of Boros Béni. He suggested the construction the 760 mm gauge network of the Alföldi Első Gazdasági Vasút (First Farm Railway of the (Great Hungarian) Plain – AEGV), where steam and benzol electric railcars and locomotives were put into service on his instructions reviving the experiments for the motorization which were abandoned after the death of Boros Béni. — Dr. Kovács László főszerkesztő: *Magyar Vasútörténet 1900-tól 1914-ig (The History of the Hungarian Railways from 1900 to 1914 – in Hungarian)*, Budapest, MÁV Rt. 1996, p. 309.
on the narrow-gauge work tracks, started the production in Germany already in the beginning of the 1860s. The construction of fast growing railway lines and networks influenced the production of the coal mines by increasing of the coal consumption directly and by increasing the demand for the industrial raw materials indirectly. The first steam locomotives appeared soon on the colliery lines replacing the horses and the first narrow-gauge public railways after the success of Festiniog Railway.

Hard working hands shaped the window-grates and the iron fences in the Gömör and Borsod bloomeries to decorate the palaces of the landowners and the corn-merchants of the city of Pest who got reach during the Napoleon wars while the industrial revolution stared slightly in Hungary. Kachelmann Károly and his son founded a plant to repair mining machines in Vihnye near Selmecbánya on the Hungarian Highlands in 1835-1838 and the building of ships started in Óbuda at the Dockyard of Duna Gőzhajózási Társaság (Danube Steam Shipping Company) in 1840. Clark Ádám have the forged chain links sent from England to the construction of Chain bridge connecting the cities of Buda and Pest, but the castings decorating the bridge were already moulded near in the foundry established by the young Swiss foundry master in the Viziváros (Watertown) district of Buda in 1844. Having opened the first steam railway line Pest—Vác in 1846, Count Széchenyi István baptized the first steamship on the Lake Balaton. Her 40 HP steam engine was built by the Penn Company in England but the wooden elements for the body of the ship were manufactured in the Óbuda Shipyards. The first steam locomotives running on the Pest—Vác railway arrived from Seraing and were built by the Belgian Cockerill Company, but the passenger coaches were already built in the Workshop of the Railway Company, set up near the Pest station. At the same time in Vienna, the representatives of the Gömöri Vasművelő Egyesület (Gömör Ironworks Union) made a bid already to the Magyar Középponti Vasúttársaság (Hungarian Central Railway Company) for the delivery of rails rolled in Ózd Iron Factory, where the machinery and the roller-frames were driven by steam engines instead of the usual water wheels from 1847. **In 1855, a new factory was established on the Resica plants of the private k. k. privilegierte österreichische Staatsseisenbahn-Gesellschaft (StEG) Railway Company, which had the headquarters in Vienna.**

The bloomeries set up close to the furnaces of the Borsod and Gömör ore fields and produced good quality armaments, steel instruments and tools, could not compete already with the West European Factories using widely the new technology of Henry Cort, the so called puddling, for the improvement of steel quality. More and more crude iron produced in Hungary was refined in Austria in the first decades of the nineteenth century. The structure of the iron industry was changed basically also in Hungary in nearly more than two decades. The bloomeries, using charcoal produced in the nearest beech tree forests and utilising the energy of the streams by water wheels, were replaced by new steel works of the level of the age. **The Henry Cort's procedure requested four or five times more coal than crude iron for the steel production.** The long distances, the absence of roads and railways and the extreme weather conditions made not possible the economical transportation of large quantity coal necessary for iron refining to the steel works set up on the ore fields in Hungary on the Highlands at that time. Therefore, new iron refineries and rolling mills were set up on the Borsod and Nógrád coal fields for the steel production, while the duty of crude iron making remained at the small furnaces of Gömör region on the Highlands. The distances from the important iron production markets in the cities of Debrecen and Pest were as important as the nearness of the coal fields at the selection of the places for the new iron refinery works. So were established the steel

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83 D. Török Béla: *A vaskohászat története a XIX. század második felében az őzdi gyár aspektusából (The History of Iron Metallurgy in the second Half of 19th Century from the Point of View of Ózd Factory – in Hungarian)*, Miskolci Egyetem Műszaki anyagtudományi Kar,
works in Borsodnádasd in 1863 near the Ózd Iron Factory of the Gömör Vasművelő Egyesület (Gömör Ironworks Union) in which the production started in 1847, the Salgótarján plats of the Salgótarjáni Vasmű Velő és Társulat (Salgótarján Iron Finery Company) in 1869 built for the re-
finery of crude iron produced in the furnaces of Gömör region\footnote{Dr. Gajzágó Aladár szerkesztő: \textit{A salgótarjáni iparvidék} (The Industrial Area of Salgótarján – in Hungarian), Nógrád megyei Munkásmozgalmi Múzeum, Salgótarján, 1962, p. 126.}, and the Diósgyőr Iron Factory built by state investments.

The number of the steam engines working in the mines, factories and industrial plants was growing fast. Their trouble free and economical operation and of course the maintenance of the machinery driven by them requested proper technical background with skilled workers. The very first small maintenance workshops appeared nearby the steam engines set up on the mining districts already in the beginning of the industrial revolution. These workshops were equipped with the required tools and constituted the basis the machine factories specialised later for the manufacturing of new products. The enterprise of Kachelmann Károly és fia (Kachelmann Ká-
roly & Son) established for the maintenance of mining machinery on the Hungarian Highlands was developed into a machine factory producing boilers, loco mobiles, agricultural machinery and equipment.

The industrial development is characterised by the production and maintenance of boilers built and put into service for feeding the steam engines used for driving the machinery. Only in the second part of 1868, 109 new boilers were put into service or repaired with total output of 3127 HP. 71 of these boilers were made already in Hungary with the total output of 2152 HP, among them were 14 boilers of 370 HP total power built by Resica Iron Factory, one boiler of 23 HP output built by the Ganz Factory in Buda and three boilers of 58 HP built by the Miskolc Workshop of Tiszavidéki Vasút (Tisza Region Railway - TVV)\footnote{A gőzkazánok, melyeknek használtatása az 1868-dik év első felében a m. k. közmunka és közlekedési minis-
terium által a kellőképpen kiállott gyakorlati vizsgálat alapján megengedetett, a következő: VEGYESEK (Steam
Boilers Authorised for Use by the Royal Hungarian Ministry of Public Works and Transport in the second half of the Year 1868 – Miscellaneous - in Hungarian) Magyar Mérnök- és Építészegyet Közlönye 3 évfolyam 2/3
(1868), p. 284-295.}.

The first narrow-gauge steam locomotives arrived in Hungary in 1870, and twenty new steam
locomotives built by Austrian and German factories were put into service on the Hungarian narrow-gauge railways in the following three years. The first steam locomotive, built in the
countries of the Hungarian Holy Crown, was the 948 mm gauge \textit{“Resica”} manufactured by the
Resica Iron factory of StEG. The \textit{“Resica”} was identical with \textit{“Szekul”} and was put into service on the Resica Factory’s industrial network a few months earlier than the first standard gauge steam locomotive built in the MÁV Machine Factory in Budapest. In 1876, also the first narrow-
gauge locomotives of MÁV Machine Factory were ready to service, which were the first
steam engines designed in Hungary.\footnote{A M. Kir. Államvasutak Gépgyára által szállított mozdonyok vázlatrajzi és méretadatok (Sketches and di-
mensions of the steam locomotives delivered by the Machine Factory of the Royal State Hungarian Railways – in Hungarian), Klösz György és fia Budapest, 1906}.

The put into service of the narrow-gauge steam locomo-
tives, built by foreign manufacturers, was continued on the Hungarian railways, but the domes-
tic builders joined to the narrow-gauge locomotive production on the request of the fast growing
demands.

\textit{The fast-growing networks of mining and industrial railways called into life also the narrow-
gauge steam locomotive production besides the standard gauge locomotive manufacturing at the same time. The industrial background necessary to produce steam locomotives already existed in Hungary in the years following the Compromise of 1867. (Thesis 2.)}
The technical characteristics of the first narrow-gauge steam locomotives built in Hungary see in Annex 2.

Describing the development of the Hungarian steam locomotive production, the number of the locomotives built in Hungary approximated already the 700, in 1894. Nearly 30 locomotives of them were narrow-gauge while the number of the steam locomotives exceeded it several times, which ran on the narrow-gauge local and industrial railways and on the tracks used for the earth works and were built by foreign factories. Beyond the demands for the construction of narrow-gauge local railways also the departmental orders helped to increase the narrow-gauge steam locomotive production. The departmental orders forced the constructors to use the products of the Hungarian industry including the rolling stock. Only the Minister of Transport, who ordered it, could give the exemption from this duty in case of well-founded reasons. The order of Baross Gábor the Minister of Commerce for the regulation of railway investments was related to the companies operated standard gauge lines, but the basic principles of it was applied in case of the construction of narrow-gauge railways.

3.1.2.1 Steam Locomotive Builders and their Locomotives

StEG Iron Factory, Resica

Resica was centre of the mining activity of the Krassó-Szörényi Erchegység in the nineteenth century. The working of iron ore fields, which were known also by the Romans, started again in the age of Queen Mária Terézia. The coal fields discovered very close to the ore mines offered ideal conditions to develop the heavy industry at the level of the age. The StEG, the owner of the Resica mines and iron works from 1855, was a railway company which constructed large standard gauge network also in Hungary. In 1864, the production of railway equipment was introduced beside the conventional iron and steel products in Resica. A new workshop was built at the bank of the Berzava River, where bridges, boilers and different equipment were produced for the company’s railway construction works carried out in Bohemia. Besides the fast increasing of the production, the construction of the narrow-gauge industrial railway network got more and more importance connecting the mines and industrial plants to each other on the large territory of the industrial area. The construction of the 948 mm gauge network of the Resica Iron Factory started in 1870. The horse traction was planned originally, but because of the difficulties experienced in the first few months of operation the lines were converted to steam traction. The length of the network exceeded already 40 km in 1873. The first steam locomotive called “Szekul” arrived from the Company’s Machine Factory of the Bécs-Győri Vasút (Wien–Raab Railway) in 1871. Three locomotives called „Resica”, „Bog-san” and „Hungária” were built on her design in Resica in 1872 and 1873. Their construction could not make any difficulties for the workers of the factory skilled in the manufacturing of railway equipment. The locomotives were put into service on the factory’s network and were used also for the railway construction works. Beyond the economic reasons also the missing connection of the plants with the national standard gauge network and the difficulties of

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87 The authorisations for the construction of second class standard gauge local railways contained the obligatory use of domestic products from 1888.

88 The Departmental Order of Baross Gábor No. 3500/1892 widened the obligation of authorisation to the new investments and rolling stock procurement or modernisation of the railway companies already in operation, offering a good possibility for the protection and enforcing of the interest of the Hungarian domestic industry. Miniszteri rendeletek tára 1892 évfolyam (Collection of the Departmental Orders, 1892 – in Hungarian) MOL.

89 Kládiva Ottmár, A hegyi bánság ipartörténete (The History of the Industry in the Mountains of Banat – in Hungarian), A Bánság enciklopédia (http://www.banaterra.eu)

transportation made the construction of the locomotives necessary in Resica. The locomotive called “Hungária” which had the running number 4 was exhibited on the Vienna World Exhibition in the next year and in the Millennium Exhibition in Budapest in 1896 as the first steam locomotive ever built in Hungary from Hungarian raw materials. The production of steam locomotives was continued according to the Factory’s growing transportation demands in Resica. Ten different 700 mm and 948 mm gauge locomotives were built in Resica for the Factory’s network until 1905, including the locomotives built on the design of the “Orient” which had 0-8-2 wheel arrangement and was constructed in the Machine Factory of Wien—Raab Railway put into service in 1873.

The technical characteristics of the locomotive “Szekul” see in Annex I.

Machine and Wagon Factory of Royal Hungarian State Railways (MÁV Machine factory), Budapest
The Machine and Wagon Factory of Royal Hungarian State Railways was established by the state procurement and union of the Hungarian—Swiss Wagon Fabric founded in the year of the Compromise and the Hungarian—Belgian Machine and Ship Building Company set up in 1868, in Budapest in 1870. The new factory dealt with the maintenance of locomotives in the beginning, but the construction of new locomotives was planned already in 1871. The first locomotive, built in Budapest was standard gauge and was put into service in 1873. It was built for the MÁV according to the design, drawings and sketches of the Vienna and Wienerneustadt Sigl Locomotive Factories and was exhibited at the Vienna World Exhibition with the locomotive “Hungária” built in Resica.

Narrow-gauge Industrial Railway Locomotives
The Factory’s duty was the design and serial production of the standard gauge steam locomotives necessary for the operation of the new constructed railways for the first, but did not rejected the unique orders for the narrow-gauge locomotives. In 1876, after three years that the MÁV Machine Factory delivered the first standard gauge steam locomotive built in Budapest, the construction of the first locomotive for the 790 mm gauge industrial railway of Salgótarjáni Kőszénbánya Rt. (Salgótarján Coal Mine Company) was finished in the Factory. The locomotive belonged to the first steam locomotive type designed in Hungary and had the unusual wheel arrangement 0-8-0 at that time. Since the Factory had not direct connection with the national railway network in 1872, the locomotive was carried on a road wagon from Resicabánya to the Oravicza railway station hauled by 24 oxen. — Klavdiva Ottmár: A hegyi bánság ipartörténete (The History of the Industry in the Mountains of Banat – in Hungarian), A Bánság enciklopédiai (http://www.banaterra.eu)

Bencze Géza, A M.kir. Állami Vas-, Aczél-, és Gépgyárak története az alapítástól a második világháború végéig (1870-1944) (The History of Royal Hungarian State Iron, Steel and Machine Factories from the Foundation to the End of WWII – in Hungarian), Bence Géza szerkesztő, Tanulmányok a MÁVAG történőtől (Studies from the History of MÁVAG – in Hungarian), Budapest, 1989, p 5-12 (Ganz Archív)

The first narrow gauge steam locomotives put into service in Hungary and built by foreign locomotive manufacturers had the wheel arrangement 0-4-0, 0-4-2 or 0-6-0. The locomotive „Orient” put into operation on the Resica Factory’s network in 1873 and the new locomotive of the colliery railway of Salgótarjáni Kőszénbánya Társulat (Salgótarján Coal Mine Company) put into service in the following year had already 0-8-0 wheel arrangement, which was unusual also in case of standard gauge locomotives, provided very good starting capability for the locomotives running on the dirty and wet tracks of the industrial railways. Villányi György: Ipar- és Bányavasutak Magyarországon, (Industrial and Mining Railways in Hungary – in Hungarian) kézirat
The locomotive production of the MÁV Machine Factory was characterised by building of the same type locomotives in large series. The number of type 28 steam locomotives built for the MÁV - as class IIIc. and later series 326 – exceeded 300\(^95\) and 400 of the type 29 - MÁV class XII later series 377 - locomotives’ by the end of the century. The standardisation was the important tool of the MÁV in order to carry out cheap and economical business management already from the beginnings including the procurement of standardised types of locomotives. The big number of same type of locomotives made easy the operation and the maintenance of the tractive stock requesting as less spare parts as possible. The MÁV Machine Factory built narrow-gauge locomotives only for the industrial railways with 0-4-0, 0-6-0 and 0-8-0 wheel arrangement between 1876 and 1896. Simple construction, low speed and output suit for the demands of the operation of 633, 790 and 1000 gauge industrial railways characterised these locomotives.\(^96\) The mines and iron factories ordered one or two or small series only of the same type of locomotives according their transportation duties. \(^97\) *This can be the reason for that one third of the 69 locomotive types was narrow-gauge, but the number of narrow-gauge steam locomotives hardly reached 50 among the 1800 built in Budapest until 1896.*

*The Hungarian locomotive manufacturers built narrow-gauge locomotives only for the industrial railway lines between 1872 and 1897. The consequent application of the principle of standardised gauge national networks, first declared by the decision of the British Parliament in 1846, hindered the wider spread of the cheaper public narrow-gauge lines as a part of the national railway networks until the end of 19\(^{th}\) century. (Thesis 3)*

**Narrow-gauge Local Railway Locomotives**

The very first real narrow-gauge local railway locomotive was built by the MÁV Machine Factory much later, in 1897. The type 42 metre gauge locomotive of 0-6-0 wheel arrangement was identical with the Sígl locomotives of MÁV Class XX put into service on the Garamberzenzence—

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95 The locomotive factories used different systems to identify their products of different technical characteristics. One of the possibilities was the system of using Arabic or roman numbers for marking the type of products following each other in time combined with Latin letters. The MÁV Machine Factory adopted using of Arabic numbers identifying the type of construction, where the upper index referred to the production series from 1890.

96 Considering the technical characteristics of the tank locomotive built for the metre gauge Bánréve—Ózd railway of the Rimamurány Salgótarjáni Vasmű Rt. with 0-6-0 wheel arrangement in 1880, it could have been able also for the operation on the third-class local railways, like the locomotives put into service in Ózd earlier. — *A M. Kir. Államvasutak Gépgyára által szállított mozdonyok vázlatrajzai és méreteadatai (Sketches and dimensions of the steam locomotives delivered by the Machine Factory of the Royal State Hungarian Railways – in Hungarian), Klősz György és fia Budapest, 1906 — Az 1878-79 évi jelentések a Bánrévé—Nádasdi vasút forgalmáról és üzleti eredményeiről (Reports about the Traffic and Results of the Bánrévé—Nádasdi Railway of 1878-79 – in Hungarian), Magyar Országos Levéltár,(a továbbiakban MOL) RMST Okmánytár, Z 366-25-904*

97 *M. Kir. Államvasutak Gépgyára Mozdony és szerkocsi jellegezés (Identification of Locomotives and Tenders - in Hungarian), Ganz-Archiv*
Selmecbánya Railway in 1872. The first 760 mm gauge local railway locomotive constructed in the MÁV Machine Factory was put into service in 1899. The type 47 tank locomotive called “Hegen” was built with 0-8-0 wheel arrangement for the order of Segesvár—Szentgotai HÉV (Segesvár—Szentgotai Local Railway) and had the running number 4. The experiences were utilised at its construction gained by the production of steam locomotives type 3, 4, 16, 19 and 34 built for the 790 mm gauge networks of the Salgótarjáni Kőszénbánya Rt. (Salgótarján Coal Mine Company) and the Petrozsény—Zsilvölgyi Railway. The locomotive, which had 0-8-0 wheel arrangement and high tractive effort was already out of date compared to the steam locomotives type 48 of Austrian design built in the same year with 0-6-2 wheel arrangement in Budapest. The locomotives were ordered for the 760 mm gauge Szatmár—Erdődi Local Railway and were put into service as MÁV class XXIa., series 396 later.99

Fig. 4. The 760 mm gauge steam locomotive Type 47 of the MAV Machine Factory, built in 1899

The requirements set up for the local railways such as the same quality of service, the speed and comfort demanded third class steam locomotives running on the narrow-gauge lines which had the same technical parameters and operational features as the standard gauge second class locomotives. (Thesis 4)

The following third class locomotive constructed by the MÁV Machine Factory was the tank type 51 of 0-8-0 wheel arrangement built for the order of the Erdélyi Bányavasút Rt. (Transylvanian Mining Railway Company - EBV) opened for limited public service.100 Its design was

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98 Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1876-tól a századfordulóig, Budapest, MÁV Rt. 1996, Vasúti vontatójárművek 1876-1900 (The History of Hungarian Railways from 1876 to the Turn of the Century -Railway Tractive Stock 1876-1900 – in Hungarian), p. 78.

99 The rigid wheel base of the type 48 steam locomotives, built on the design of the Wienerneustadt Locomotive Factory, was only 1800 mm, comparing to the 2280 mm of the locomotive “Hegen” built on the experiences of the industrial locomotive heritage of the MÁV Machine Factory. The permitted speed of the type 48 was 30 km/h meeting the requirements of the long third-class railways lines built from the 1890s. Their boilers were built with inclined fire box back and door plates, first time in Hungary, reducing the weight of the locomotives and making easier the installation of the cab fittings, as well. — Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1876-tól a századfordulóig, Budapest, MÁV Rt. 1996, Vasúti vontatójárművek 1876-1900 (The History of Hungarian Railways from 1876 to the Turn of the Century -Railway Tractive Stock 1876-1900 – in Hungarian), p. 79.

100 The iron ore transportation began on the 760 mm gauge line of Erdélyi Bányavasút Rt. (EBV) in 1900. The 16 km long railway connected the upper plant of the Vajdahunyadi Magyar Királyi Állami Vasgyár (Royal Sate Iron Factory Vajdahunyad) with Retisora Station built close to the Gyulár iron ore mine. The railway crossed the village of Govasdia, and soon the limited public service was installed to fulfil the transportation demands of the neighbouring settlements. The EBV ordered three locomotives from the MÁV Machine Factory to handle the traffic. — Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1876-tól a századfordulóig, Budapest, MÁV Rt. 1995, Vasúti vontatójárművek 1876-1900 (The History of Hungarian Railways from 1876 to the Turn of the Century -Railway Tractive Stock 1876-1900 – in Hungarian), p. 83.
based on the standard gauge type 29 steam locomotives built in large series for the second class local railways. The type 51 locomotives had unusual long wheel base and the Klien-Lindner axles were applied to negotiate the small curve radii, first time on the locomotives built in Hungary.\textsuperscript{101} Their tractive effort was higher than of the type 29, MÁV Class 377 locomotives. The higher tractive effort ensured a good feature for the locomotives because of much higher rolling resistance of the wagons running on the narrow-gauge lines compared to the standard gauge wagons and carriages.\textsuperscript{102, 103} They had 24 t service weights which were too heavy for the Hungarian third-class lines built for 5.5 t axle load. Only seven type 51 locomotives were built for the EBV and the Rózsahegy—Koritnicai HÉV (Rózsahegy—Koritnicai Local Railway), between 1900 and 1915.

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{steam_locomotive.png}
\caption{The steam locomotive of the MAV Machine Factory, Type 51, built in 1900}
\end{figure}

The Annex 3 contains the technical characteristics and comparing calculations of the MÁV Machine Factory’s type 29 standard gauge and type 51 narrow-gauge locomotives.

The one unit of type 69 locomotives was among the narrow-gauge locomotives built by the MÁV Machine Factory for the order of Erdélyi Erdőipari Rt. (Transylvanian Forest Industry Co.) in 1904. It was the wood fired version of the type 51 locomotives.\textsuperscript{104} Utilising the construction of type 51 locomotives the great area was increased a little to suit for the use of wood

\textsuperscript{101} The Klien-Lindner axle was applied widely on the narrow-gauge steam locomotives to negotiate the small curve radii. It consisted of the hollow and the driving axle installed inside. The hollow axle had two parts which were fastened by nuts and bolts to each other at the middle section. The driving axle was mounted to the outer frame of the locomotives with axle boxes. A special spherical joint connected the two axles together which made possible for the hollow axle the swivel and the lateral movement, as well. Therefore, the hollow axle equipped with the tyres could turn into the direction of the radius of the curve, independent from the driving axle, by the effect of the forces acting on the wheel flange. The hollow axle moved in the lateral direction was forced back by springs into the central position, but Klien-Lindner axles without springs were also used. The tractive effort was transmitted to the hollow axle via pivots. The Klien-Lindner axles mounted on a locomotive were connected to each other with rodding to adjust the rear end axle also into the direction of the radius of the curve. — Kopasz Károly: \textit{Gőzmozdonyok (Steam Locomotives – in Hungarian)},Tankönyvkiadó, Budapest, 1960, p. 279.

\textsuperscript{102} Dr. Ing. F. Meineke, \textit{Die Dampflokomotive}, Springer Verlag Berlin 1949, p. 6.

\textsuperscript{103} Keskenynyomközű 485, 490, 495, 496, M297, M268 sor. mozdonyokkal végzett terhelési próbák (Loading Tests of the Narrow-gauge Class 485, 490, 495, 496, M297, M268 Locomotives – in Hungarian), 1959, MÁV Anyagvizsgáló főnökség, MÁV Dokumentációs központ és Könyvtár

\textsuperscript{104} The coal firing was widely used on the steam locomotives in the second half of the nineteenth century. The big amount of industrial waste gathered in the wood mills and agricultural estates offered good possibility for the utilisation as fuel of the boilers used for generating steam and replacing the expensive coal. The lower heating quality and the ash made necessary to modify the construction of the boiler. The dimensions of the great area were determined by the required amount of steam necessary for the traction capacity. More amount of lower heating quality fuel was necessary to be burned for producing the same traction capacity. The heating quality of fuel determined also the rate of the heating surface and the grate area at designing of the steam locomotives. The different features of the fuels made necessary minor changes in spark arrestors, in the construction of the great and
The production of locomotives type 51, utilising the elements of standard gauge type 29 and 39 steam locomotives, was also an impasse for the steam engines of 760 mm gauge lines besides the locomotive „Hégen” designed on the bases of the experiences gained by the earlier construction of industrial locomotives. Having put into service the locomotives it became evident in a short time, that the traffic of the Hungarian 760 mm gauge third class local railways did not required heavier locomotives running on stronger bridges and superstructure than 5,5 t axle loads at the end of the century. The narrow-gauge local railways required locomotives running at top speed of 30-35 km/h in passenger service. The industrial railways invented limited public service required steam locomotives running on the tracks built with small curve radii and 60 % inclines. The experiences gained by the design and production of type 51 and 69 locomotives made possible the construction of the locomotive type meeting the requirements both of the public service and the industrial transportation, and keeping and development of the good technical features of type 51, and which fulfilled also the special demands of forest railways. Its

the places used for the storage of fuel. The wood fired locomotives were built with Klein type turbine spark arrestors and grate rods laid down in higher density.

105 The Klein type spark arrestor chimney was the typical equipment of steam locomotives built with short smoke box. The chimney consisted of two conical plates fastened to each other. The smoke, streaming out of the boiler, was forced to change its direction by a turbine installed in the upper part of the chimney. The heavy glowing sparks fall gathering at the bottom of the chimney and was removed frequently via the slots opened for it. Later, when the speed of the locomotives was increased, the height of the lower part of the chimney was decreased significantly to eliminate the bed influence of the smoke generated by the vacuum of the chimney. The Klein type spark arrestor chimney disappeared from the standard gauge locomotives by the introduction of American type smoke boxes. The narrow-gauge locomotives built for wood or light brown coal firing was built with Klein type chimneys even after the WWII. — Dr. Kovács László főszerkesztő: Magyar Vasúttörténet A kezdetektől 1875-ig, Budapest, MAV Rt. 1995. Gözmozdonyok (The History of the Hungarian Railways from Beginnings to 1875- Steam Locomotives – in Hungarian), p. 296-336.

106 The use of inclined fire box back and door plates became general by the end of the century despite that it was predisposed for generating scale because of the least favourable streaming conditions.

107 The requirement for the locomotives built for the forest railways was the operation on the sidings and on the old line sections, constructed for horse traction, without limitations avoiding the necessary expansive track reconstructions. Therefore, the boilers of the locomotives were constructed to run on the 60 % slopes while remaining the fire box and the smoke tubes under water. The locomotives of 0-8-0 wheel arrangement were built with Klien-Lindner axles taking into consideration to negotiate of the small curve radii. The fuel of the locomotives was the waste of the wood mills generally. Injectors, installed on the locomotives operated by steam, were used to feed the water tanks of the locomotives from the wells and rivers. It made unnecessary the setup of water stations on the lines, which were used only seasonal only in the year.

108 The traffic of the forest railways required high power steam locomotives of more than 6 t axle load only after the WWII.
boiler was able with minor modifications also for burning the fuel of low quality like wood and brown coal.

**Standardised Type Narrow-gauge Steam Locomotives of the MÁV Machine Factory**

The Hungarian factories producing railway equipment got less and less order because of the economic crisis influenced the construction of secondary railway network unfavourably.\(^{109}\) The number of steam locomotives produced was decreased to the half by the turn of the century and to one fourth by 1904 comparing to the outstanding production of 1896. **The lack of orders, the fast growing popularity of narrow-gauge railways, and the burn down of the Arad work’s boiler smith shop forced the MÁV Machine Factory to build narrow-gauge steam locomotives, which was involved mainly in the production of first and second class locomotives earlier.**

The limited public service was introduced on some industrial railways built newly or earlier. Passenger and mixed trains also were running on the determined section of their lines built for freight traffic. The economical operation of these networks, the reduction of the investment and maintenance costs requested standardised type locomotives which can fulfil the special demands of the different railways with minor modifications. The narrow-gauge locomotives meeting the requirements of industrial railways were characterised by strong tractive effort and safety running in sharp curves, steep gradients and narrow loading gauges of the mining railways. The loading gauge of the third class railways was larger according to the demands of the public service. The 30-35 km/h speed of the trains running on the narrow gauge local railways became very important requirement before the turn of the century. **The building of standardised types for the order of different contractors shortened the production time of the locomotives significantly and decreased the production costs.**

**The construction of narrow-gauge railways and the demand for the rolling stock running on them raised the necessity of standardisation.**

**The MÁV Machine Factory left its heritage and started to build standardised type locomotives for the order of different narrow-gauge railway companies - excluding the special cases - from the middle of the first decade of the twentieth century, fallowing the practice of the Austrian and German locomotive factories.**

*(Thesis 5)*

**Locomotives type 70 of the MÁV Machine Factory**

The Royal Hungarian Ministry of Finance sponsoring the railway construction works ordered three locomotives from MÁV Machine Factory for the 760 mm gauge network of Görényvölgyi Erdei Vasutak (Görgény Valley Forest railway - GEV) in 1904 to carry the woods cut in the Royal Hungarian Forest estate of Szászrāgen. The GEV’s 15,6 km long Szászrāgen—Libánfalva main line, started from the Szászrāgen MÁV station, was opened for the limited public service. The 22 km long network of industrial sidings was connected to the main line built with sharp curves and 60 %o gradients. On the 4th of September 1905 started the regular service on the GEV carrying the woods cut in the Royal Hungarian Forest estate of Szászrāgen. The MÁV Machine Factory based on its more decades of experience in building narrow-gauge steam engines designed a new eight-wheeled type tank engine for 760 mm gauge and 5,5 t axle

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\(^{109}\) The expenditures of the millennium year 1896, the economic policy of the 1890s and the collapse of the guaranteed interest system supported the construction of secondary railway network resulted the exhaust of the Hungarian State Treasury which financed the investments. Because of the decreased demand for the railway equipment 1000 workers had to be dismissed from the Diósgyőri Vásgyár (Diósgyőr iron Factory) in 1901. — *A Diósgyőri Magyar Királyi Vas és Acélgyár története. (The History of Royal Hungarian Iron and Steel Factory, Diósgyőr – in Hungarian) 1765-1910*, 1910, p. 15.

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load, equipped with Klien-Lindner axles. The type 70 locomotives joining the features of industrial and local railway narrow-gauge locomotives could run on the Szászrégen—Libánfalva main line of the network, servicing public transportation, and also on the industrial sidings connected to the main line and excluded from the public service.

The main technical features of the type 70 locomotives, built first in 1905, were the same as the wood fired version of the draft eight-wheeled tank locomotives designed as offer for the Szombathely—Pornói Vasút (Szombathely Pornói Railway) in 1904, but in some small details the locomotives were improved and bettered. The Hall-type cranks were replaced, the distance of the mainframe plates was increased, and the steam piping was simplified decreasing the resistance of the steam flow into the cylinders and into the chimney.

The main frame of the locomotive was made from 17 mm thick steel plate. The cylinders, having Stephenson valve gear, were outside of the framing. The diameter of the wheels was 750 mm. The first and the fourths axles were equipped with Klien-Lindner hollow axles. With the rigid wheel base of 1150 mm the locomotives could run on in 30 m radius track curves. The bolted boiler made from 12 mm thick steel plates had 14 bar steam pressure. The fire box made from copper plates had 1,04 m² grate area. Inside of the of 916 mm diameter boiler the number of 40 mm diameter smoke pipes was 128 with the length of 2700 mm. The heating surface of the boiler was 48,14 m². The locomotives, because of wood firing, were delivered with Klein type chimneys equipped with turbine spark arrester. There was a large 3 m³ area in the driver’s cab for the storage of wood. The power of the locomotives reached 120 PS (88,3 kW) in case of wood firing. The first three type 70¹ locomotives with the production number of 1810-12 were put into service in Szászrégen on 31st of august 1905.

![Fig. 6. The Type 70¹ steam locomotive of the MAV Machine Factory, built in 1905](image)

The contractor of the 51 km long Szatmár—Bikszádi HÉV (Szatmár—Bikszádi Local Railway) was required to buy the material and the rolling stock from Hungarian factories. The MÁV Machine Factory built two coal fired type 70 locomotives for this order. The construction works began on the Local Railway in March of 1905. The new line had a connection at Szatmárnémeti Kossuth kert station to the Szatmár—Erdődi and Nagykároly—Somkuti HÉV (Szatmár—Erdődi and Nagykároly—Somkuti Local Railway) lines operated by MÁV, making a big 760 mm network in that region. The new line’s first 35 km long section leading to Avasújváros from Szatmárnémeti ran on the plains. The rest of the line from Avasújváros to the famous salt bath of Bikszád climbed up on a gradient of 18 % with 80 m curve radius through the Valley of Avas Mountains. The driver’s cab of the coal fired type 70³ locomotives was modified to carry 800 kg coal. The balance-weights integrated with the outside cranks were put on the wheels. Better balancing of the driving-gear made possible the increase of the speed to 30 km/h. The locomotives were equipped with safety chain connection besides the central buffers installed outside of the frame and with train steam heating device according to the demands of the local railways. The power of the locomotives reached 150 HP (110 kW) in the case of firing with
MÁV Standard coal. The first two type 70³ locomotives, classified XXIc. 6967-6968 steam engines were put into service on the railway in the spring of 1906. In 1908 a further four type 70⁴ locomotives were delivered to the Szatmár—Bikszádi Local Railway.

On the bases of the good experiences gained by the first two locomotives, soon the delivery of the first locomotives was followed by a large number of orders. The type 70 locomotives became a basic steam engine type, in a short time, on the 760 mm gauge 5,5 t axle load lines built in the Carpathian basin before 1920. Their good features, the ability to negotiate sharp curves, the large boiler capacity and the ability to take overweight loads made them economically viable on both the local and industrial networks of forest and mining railways, compared to the Austrian and German locomotives built for similar duties and running on the Hungarian narrow-gauge lines. Soon, the delivery of the first locomotives was followed by a large amount of orders. Until the end of the WWI 31 units were put into service on the Szatmár—Bikszádi, Torda—Topánfalva—Abrudbányai and Maros-Tordai narrow-gauge local railway lines operated by MÁV. Further eight units were delivered and put into service on the occupied territories during the WWI, on the request of the War Department. Nine units of type 70 locomotives were delivered to the forest railways including the locomotives of GEV and to the industrial network of Oroszka Sugar Factory.

The Annex 4 contains the technical characteristics of type 70 narrow-gauge locomotives.

**Miscellaneous Narrow-gauge Steam Locomotives**

The MÁV Machine Factory produced and delivered two new narrow-gauge locomotive types in every year from the turn of the century until 1903. The narrow-gauge locomotive production was characterised by building of small batches such as before. The new locomotives were the modernised version of steam engines built earlier or the domestic version of the foreign types put into service earlier in Hungary, but more and more new narrow-gauge locomotive types were designed in the MÁV Machine Factory. For example a miscellaneous tank locomotive of 0-10-0 wheel arrangement were also designed for 3.6 t axle load and equipped with Klien-Lindner axles but it was never built because of the lack of orders. The production of steam locomotives was finished in the Weitzer János Gépgyár in Arad after the fire burned out the boiler smith workshop in 1904. The MÁV Machine Factory took over the production of the BHOV 760 mm gauge Klose system steam locomotives, contracted for the Arad Factory earlier. The last four of the 26 Hungarian built BHOV IIIa5 locomotives were manufactured in Budapest as type 63.

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*Fig. 7. The heavier version of steam locomotive BHOV Class IIIa5, built in Budapest by the MÁV Machine Factory as type 63 in 1904.*
Locomotives type 66 of the MÁV Machine Factory

Five new type of narrow-gauge locomotive was built in the MÁV Machine Factory in 1904. The type 66 locomotive was among them which was built with unusual 2-2-2 (A1A) wheel arrangement and equipped with De Dion et Bouton system boilers and steam engines designed and manufactured originally for road vehicles, buses and lorries. The Alföldi Első Gazdasági Vasút (First Farm Railway of the (Great Hungarian) Plain – AEGV) ordered two steam locomotives which could run with heavier passenger trains on the market days keeping the same time table on the Békéscsaba—Vésztő line as the steam railcar service. The MÁV Machine Factory delivered the new locomotives in 1904 and 1905, each equipped with two De Dion et Bouton system boilers and steam engines of 50 LE (36.8 kW) applied on the Ganz railcars. The two boilers and steam engines doubled the power of the locomotives comparing to the railcars. The two-cylinder compound steam engines drove the front and rear axles of the locomotives via two stage gear drives. The high pressure 18 bar boilers were installed in the middle of the locomotives and had a large cover common with the driver’s cabs like the tramway locomotives. The water and coal tanks were outside, in front of the driver’s cabs above the driving axles. The locomotives could run at 35 km/h authorised top speed in both directions. The chimneys of the boilers firing with charcoal were equipped with Klein system spark arrestor. The Borzsavölgyi Gazdasági Vasút (Borzsa Valley Farm Railway - BVGV) put into service four further locomotives of type 66 on its more than 100 km long network.

The locomotives operated reliable. The high-pressure boilers and high rotation steam engines constructed for the road vehicles met also the requirements of the narrow-gauge railways. Their power capacity was the same 100 LE (73.6 kW) as of the 760 mm gauge steam locomotives MÁV class XXIb, - series 289 after 1911 – built in Arad for the Torontáli HÉV (Torontál Local Railway) and could run by 35 km/h authorised top speed in both directions. Only the procurement of good quality charcoal was unusual in the railway operation. The railcars equipped with internal combustion engines and electric power transmission put into service at the same time offered cheaper railway operation, hindering the wider spread of the steam railcars.

The Annex 5 contains the technical characteristics of type 66 miscellaneous narrow-gauge locomotives.

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110 The trains running on the quiet week days, hauled by light steam railcars, could not fulfil the requirements of the heavy passenger traffic of market days economically. The steam locomotives of double power capacity made it possible to couple two or three covered vans to the passenger trains which carried the goods sold at the city markets. — Sármezey Endre: Motorüzem a vasutakon (Railcar Service on the Railways – in Hungarian), Wodianer, Budapest, 1909
Machine Factory of Kachelmann Károly and Son, Vihnye

The settlement Vihnye, famous of its iron thermal bath, laid down on 310 m high in a pleasant valley joining on the right side to the River Garam at the village of Szénásfalu. It was a settlement of German miners originally and the property of the city of Selmecbánya from 1563. Hesszeni Sarolta Amália the wife of the prince Rákóczi Ferencz II came here to have some rest in 1696. In 1703-04 and in 1708 the prince himself visited the settlement. Vihnye was a prospering mining and industrial plant in the nineteenth century with a famous gold and silver mine operating in its boundary. The Machine Factory of Kachelmann Károly and son comprised an industrial plant under the bath. The plant established for the maintenance of mining machines dealt with the production of agricultural machinery, loco mobiles and boilers according to the demands of the age. The factory produced also three 750 mm gauge steam locomotives between 1879 and 1883. The locomotives were put into service on the industrial railway of Zólyombrézői Magyar Királyi Állami Vasgyár (Royal State Hungarian Iron Factory Zólyombréző).

Weitzer János Machine Factory and Foundry, Arad

The Weitzer János Gépgyár és Vasöntőde (Weitzer János Machine Factory and Foundry) in Arad was established in 1891. The production of steam locomotives built mainly for the secondary and narrow-gauge lines started in 1896. Its most famous and best known products were the MÁV class XII, (series 377) standard gauge locomotives built on the design of the MÁV Machine Factory type 29 locomotives, the 760 mm gauge locomotives of the later MÁV series 385 built with 0-6-0 wheel arrangement for the AEGV and the Gyulavidéki HÉV (Gyulavidéki Local Railways), the locomotives of the later MÁV series 289 built with 0-4-0 wheel arrangement for the Torontáli HÉV (Torontáli Local Railways) of the and the Klose system locomotives of 0-6-0 wheel arrangement built for the BHOV. The production of steam locomotives was finished in Arad as the smith shop was burn down in 1904. The Arad Factory built 132 steam locomotives between 1896 and 1904, and 65 were narrow-gauge among them. The steam locomotives built for the BHOV were the most developed products in this category of the age.

Characterising the demand for the narrow-gauge locomotives at the turn of the nineteenth and twentieth century the Arad Factory built as many locomotives between 1896 and 1904 as the MÁV Machine Factory in the previous 30 years. The half of the locomotives was built for public service and the rest for the industrial railways.

Steam Locomotives of MÁV class XX1b. (Series 289)

The Arad Factory, recognising the importance of the mean speed of the trains running on the long narrow-gauge local railway lines, built 760 mm gauge steam locomotives of 30 km/h authorised maximum speed for order of Torontáli Local Railways operated by the MÁV, proceeding the MÁV Machine Factory. The six locomotives of 0-4-0 wheel arrangement were put into service in 1898.

The Annex 2 contains the technical characteristics and power calculations of the locomotives.

The locomotive type, which construction met the most sophisticated theories of its age, was not able for general use on the Hungarian narrow-gauge local railways. The power of its boiler could be utilised only at high speeds. Because of its 0-4-0 wheel arrangement it was not good for the mixed train traffic characterised the operation of narrow-gauge railways. The type of the locomotives could be ideal for hauling passenger trains of local railways running on the plain

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111 Rudolf trónörökös ő császári és királyi Fensége, József főherceg ő császári és királyi Fensége, Fülöp Szász-Koburg-Gothai herceg ő Fensége: Az Osztrák Magyar Monarchia írásban és képekben (The Austro-Hungarian Monarchy in Writing and Pictures – in Hungarian), Magyar Királyi Állami Nyomda, Budapest, 1885-1901 Országos Idegen nyelvű Könyvtár, Budapest
lines with separated passenger and freight traffic, but the successful introduction of steam railcars in 1901 made unnecessary the serial production of the locomotives.

The Steam Locomotives of BHOV Class IIIa5

The fast enlarging network of the BHOV, ran from the River Száva to the bank of the Adriatic Sea, was connected at one point only to the standard gauge network of the Monarchy at the MÁV Boszna Bród Station. The BHOV got more and more importance in the transportation of Hungarian export products besides the standard gauge MÁV Zágráb—Fiume line at the turn of the century. According to the dualistic governing principles of the Monarchy applied on the occupied territories, the BHOV ordered one part of its locomotives at the Hungarian manufacturers. The Weitzer János Machine factory built 22 Klose system compound steam locomotives for express passenger service in Arad between 1899 and 1902.

![Fig. 9. The steam locomotive of BHOV Class IIIa3, built in Arad in 1899-1902](image)

The technical characteristics of steam locomotives built by the Weitzer János Machina Factory in Arad and the power calculation of the MÁV series 289 steam engines can be found in Annex 6.

3.1.2.2 Railway and Industrial Railway Workshops

The maintenance workshops of the first railway companies repaired and produced new rolling stock in the beginning but these activities were specialised and separated soon as the networks became larger. The miniatous, the reconstruction of the locomotives to meet the new operational requirements and the reparation of locomotives damaged in the collisions required special practice and tools different from the factories set up for serial production and remained the duty of the workshops. The first separated locomotive factories independent from the railway workshops specialised for the maintenance and repair of locomotives carriages and wagons were founded in the middle of the nineteenth century. Despite the separation the factories repaired locomotives and the workshops built also new rolling stock on special request and demands. The MÁV Machine Factory rebuilt five locomotives for the TVV in 1880. The MÁV Északi Workshop converted six MÁV Class II passenger locomotives to class IIb express locomotives in 1881 and 12 local railway locomotives of 2-4-0 wheel arrangement taken over from the Magyar Nyugoti Vasút to MÁV class XIIl. compound engines of 0-6-0 wheel arrangement.112, 113 The Nyugati Workshop of the OMÁV in Budapest built a new ÁVT class Vd. (MÁV class TIV., series 450) tank locomotive in 1886. The other eight locomotives of the class were built by StEG Vienna Machine Factory for the Oravica—Anina line in 1881-84.

113 Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1876-tól a századfordulóig, Budapest, MÁV Rt. 1996. Vasúti vontatójárművek 1876-1900 (The History of Hungarian Railways from 1876 to the Turn of the Century -Railway Tractive Stock 1876-1900 – in Hungarian), p. 53-54.
Expressive development was made in the Ózd Factory of the Rimamurány-Salgótarjáni Vasmű Rt. (Rimamurány-Salgótarjáni Ironworks Co -RMST) by the influence of the increasing demand for the products of the steel industry at the end of the nineteenth century. The Ironworks Company, keeping its steel producing capacity of the quality products in the Gömör region, focused the centre of iron and steel mass production to its Ózd plants. The development of the Ózd factory was started with the invention of new steal production process. New rolling mill was set up connected to the Siemens-Martin furnaces. The new blast furnaces started the rude iron production after the turn of the century. New standard gauge local railway operated by the MÁV took over the passenger and freight transportation on the Bánréve—Ózd and Center—Bánszállás lines on 12th of June 1887, replacing the metre gauge industrial railway. The traffic of the Ózd—Nádasdi Vasút (Ózd—Nádasdi Railway - ÓNV) increased significantly despite the shortening of its metre gauge network. The increasing traffic made necessary also the development of the maintenance facilities of the rolling stock. An industrial railway workshop was set up on the territory of the Ózd Factory in 1891. A loco shed for storing four locomotives was built in 1892. The working of the coal fields started in the Somsály Colliery in 1900, and a new 2,5 km long metre gauge industrial siding was constructed for the coal transportation which was connected to the Ózd—Nádasdi line. The increasing transportation demands requested new rolling stock. The first locomotive boiler was built in the ÓNV Workshop of the RMST, in 1898. Two new steam locomotives were built in Ózd in 1901: a new 520 mm gauge steam locomotive for the Rákos—Szirki Mining Railway which transported the ore worked out from the Company’s Rozsnyó Iron Mine, and another 1000 mm gauge steam locomotive for the ÓNV. The metre gauge locomotive called „Arló” was built on the design of the Sigl locomotives of 0-6-0 wheel arrangement, put into service in 1872.

The Factory of Salgótarjáni Vasifinomító Társulat (Salgótarján Iron Finery Company) established in the valley of the Creek Tarján in 1868 developed to a significant plant nearly in 10 years. 15 % of the Hungarian rude iron production was refined in Salgótarján in 1879, while the Company’s colliery produced more than 86 000 t coal yearly. A 790 mm gauge rack railway of system Riggenbach was built for the transportation of the coal from the Collieries to the Factory. The rack railway replaced the 790 mm gauge industrial railway, built earlier with rope railway sections, in 1881, in the year when the Gömör Vasművelő Egyesület (Gömör Ironworks Union), the owner of the refinery works in Ózd and Borsodnádsd and blast furnaces in the Gömör region, united with the Salgótarjáni Vasifinomító Társulat (Salgótarján Iron Finery Company) and established the very important concern of the iron works and plants working in the northern region of Hungary, called Rimamurány-Salgótarjáni Vasmű Rt. (Rimamurány Salgótarjáni Ironworks Co.). The transportation capacity of the new 5380 m long railway running from the Factory’s Boiler House up to the loading point I of the Salgó Mine Head was 300 t coals per day. The locomotives of 0-6-0 wheel arrangement built by the Karlsruhe Maschienenbau Gesellschaft hauled the trains on the lower adhesion section of the line between

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114 The loco shed of the ÓNV in Ózd was enlarged for storing ten locomotives in 1907, because of the increased number of the steam engines run on the factory’s industrial network. Thirteen steam locomotives were operated on the fast-developing industrial network of the Ózd Factory in the next year. Three locomotives were built for normal gauge adhesion and three for mixed rack and adhesion service, five, metre gauge and two 635 mm gauge. — Vass Tibor. Az Ózdi iparvasút története (The History of Industrial Railways of Ózd – in Hungarian), 2001. Budapest, Közlekedési Múzeum, p. 31-32.


116 A Rákos—Szirki Bányavasút gőzmozdonyokkal való közlekedés engedélyezése, (Authorization for the steam traction on the Rákos—Szirki Mine Railway – in Hungarian) MOL RMST Okmánytár Z366 1272
the Factory and the Well House. Two new tank locomotives were put into service to run on the upper rack and adhesion sections. The locomotives were built by the Wiener Lokomotivfabrik Floridsdorf with 0-4-2 wheel arrangement. The operation of the locomotives on the rack railway built with the narrowest gauge was not free from the difficulties. One of the locomotives was damaged seriously at a collision caused by a break away. The management of the factory made a connection with the Schweizerische Lokomotivfabrik (SLM) of Winterthur after the collision to replace the damaged locomotives. Having studied the rack railway service in Salgótarján by its experts, the SLM delivered two new locomotives built for running on the adhesion and rack line sections in 1883. These locomotives were the first built for mixed, adhesion and rack traffic by the SLM Factory established in 1873.

The task of the Salgótarján Workshop, working under direction of the Salgó Mine Board of the RMST, was the maintenance and the manufacturing of the new machinery used by the steel works and collieries of the Company. The Salgótarján Workshop accepted also private orders frequently, but the significant part of its capacity was engaged by the production of the transportation equipment: mine cars and mine car wheel sets, and also the turn tables, and later the current collectors built for the electric locomotives of the mine railways. New steam locomotives were built in Salgótarján Workshop, one for 650 mm gauge lines of Salgótarján Mines in 1899 and another of 0-4-0 wheel arrangement and 520 mm gauge in 1901. New rolling stock was put into service on the 790 mm gauge Salgótarján Rack Railway a new rack railway locomotive among them in 1904 identical with the SLM locomotives put into service in 1883.

The Annex 7 contains the technical characteristics of narrow-gauge steam locomotives built by the Workshops of RMST.

The workshops of the industrial railways joined to the locomotive builders answering the challenge for the increasing demand of the narrow-gauge steam locomotives at the turn of the century. (Thesis 6)

3.1.3 The Inventions and Innovations on the Steam Locomotives

The development of steam locomotive production was characterised by the demand for the higher speed and traction capacity of steam engines running on the main lines in the last third part of the nineteenth century, combined with the improvement of the efficiency and bettering the construction of the locomotives. The boiler pressure of the locomotives was increased from 8-8.5 to 14 bars in this period. The invention of the compound engines improved the efficiency of the locomotives and decreased the specific coal consumption but the demand for the higher power capacity increased the weight of the locomotives from 38-40 up to 55-60 t, which made necessary to invent the heavier axle load for the locomotives, to increase the number of coupled wheels and to apply running wheels. The higher speed and power capacity made necessary to introduce some other inventions like the air brakes and the pop safety valves.

The development of the narrow-gauge steam locomotives followed slowly the first and second class engines. It was characterised by a strange duality until the turn of the century. The third

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117 Two teeth of the cog wheel of the locomotive on the way running up to Salgóbánya brake out in the morning hours of 2. February of 1883. The train rolled back from the upper end of the first steep cog wheel section down to the Well House Station. The train derailed in the last curve before the Station and fall into the valley. Seven men died in the collision among the fireman of the locomotive. The reason of the accident was the bad quality of cog wheel made from bronze. — Vertich József, Volt egyszer egy fogaskerekű (Once there was a Cog Wheel Railway), Múzeumbarátköri könyvek (MÁV Zrt. Dokumentációs Központ és Könyvtár)

118 Plananarchiv SLM, SBB Historie, Winterthur, Svájc

119 MOL RMST Salgóbánya Z 1321-9-44 Gépműhely
class 760 and 1000 mm gauge local railway locomotives were the reduced versions of the standard gauge engines in the beginning. The traffic of the industrial railways requested locomotives of low speed and high tractive effort which could run safety also on the bed repaired, often polluted, small curved and high gradient track section of the factories and the mines. Their construction gauge of the locomotives met often the dimension of the underneath gangways or the gates of workshops. The 0-8-0 wheel arrangement appeared on the industrial locomotives even in the 1870s. To increase the speed was not demanded on the narrow-gauge lines for a long time. The increasing transportation demands could be fulfilled easy by putting into service new locomotives in the most cases. Running of the twin locomotives operated by one fireman and one driver, and also of the miscellaneous Fairlie-, Garratt-, Mallet- and Meyer system locomotives could even double the transportation capacity of the lines. Running with higher speed of the trains led also to the increase of the transportation performance, requesting locomotives of higher capacity. By the end of the 1880s the invention of the metre gauge loading gauge, the 6-8 t axle load and also the Klose system for negotiating the curves -also on the steam locomotives, passenger carriages and on the freight wagons - made possible to increase significantly the speed of the steam locomotives built for the 760 mm gauge Bosnia-Herzegovinian lines which developed to a national network in nearly twenty years. The general invention of the Klien-Lindner axles made possible to run the locomotives of 0-8-0 wheel arrangement on the tracks built with 30-40 curve radii.

The invention of the Klien-Lindner axles helped the construction of the standardised type locomotives making possible to operate the same types on the industrial railways.

The development of the mechanical engineering and the metallurgy made possible to build small power capacity narrow-gauge steam engines with improved construction. By the end of the nineteenth century, the development of steam locomotive production reached the stage when the factories could construct and build steam locomotives of the same speed and of the same power capacity for the 760 mm gauge lines as of running on the secondary local railways.

3.1.4 The Influence of the Austrian and German Locomotive Factories on the Hungarian Locomotive Builders

Some of the first steam locomotives put into service in Hungary arrived from the Austrian locomotive factories. The first locomotives built in Hungary were also designed in Austria.120 The Weitzer János Machine Factory and Foundry also built locomotives of Austrian design for the Hungarian railways and the BHOV in Arad, besides the MÁV Machine Factory and the Resica Iron Factory of the StEG. The production of locomotives designed in foreign or other national factories was in general practice also at that time. The big railway companies purchased their same type locomotives from many factories because of their limited manufacturing capacity or of industry political reasons. In the other hand the introduction of the new locomotive types could have lasted too long. So, in many cases more than one factories were contracted to produce the same locomotive class. Also the Austrian and German locomotive factories built locomotives designed by the MÁV Machine Factory for the MÁV and for the Kassa Oderbergi Vasút Társaság (KsOd). Also the Weitzer János Machine Factory and Foundry of Arad built steam locomotives designed in Budapest. The production of some successful types was taken over by other factories, which produced the locomotives for a third part. Many Austrian design steam locomotives were built in Arad and in Budapest for the Déli Vasút (Southern Railway -

120 Although, Type 1 locomotives of the MÁV Machine Factory were built still according to the technical documentation made by Fehringer, the chief designer of the Sigl Locomotive Factory Wienerneustadt, a new boiler was constructed for the Type 2 locomotives already in Budapest. The first narrow gauge steam locomotive was manufactured in Resica, on the model of the locomotive „Szekul” built in the Machine Factory of the Bécs—Győri railway on the design of John Haswell. — Fialovits Béla: A M.Á.V. gőzmozdonyainak történeti fejlődése I-II. rész (The Historical Development of MÁV Steam Locomotives, part I-II: - in Hungarian). TECHNIKA 1941/4 p. 136-145., 1941/6 p. 217-225 — Ulrich Antal, A Resica-Szekuli keskenyvágányú vasút leírása (The Description of Resica—Szekul Narrow Gauge Railway — in Hungarian), Magyar Mérnök- és Építész-Egylet Közlönye 9/11 (1875), p. 466-474.
DV), the KsOd and for the BHOV on the Departmental Order of Baross Gábor the Minister of Commerce. The taking over and the production of the construction elements was more important than the manufacturing of foreign locomotive types. For example the Haswell type wavy fire box top which made possible to build the firebox without crown stays and was applied on several types of the MÁV Machine Factory, also the Brotan boilers of which more than 800 were built for the MÁV locomotives in the MÁV machine Factory.

It is just possible that the success of the 760 mm gauge local railway tank locomotives class U (Unzmarkt) of the kaiserlich-königlichen Staatsbahnen (kkStB) built with 0-6-2 wheel arrangement from 1897, forced the locomotive constructors of the MÁV Machine Factory to design new narrow-gauge local railway locomotives of similar good characteristics.121

The Steam Locomotives of the BHOV

A national 760 mm gauge network was constructed and developed connected to the Bròd—Szarajevò line in the occupied Bosnia-Herzegovinian province in nearly two decades. Its main line reached via Mostar the Dalmatian border and the bank of the Adriatic Sea at Metkovic near the today’s Dubrovnik in the 1890s. Local railways and sidings were connected to the main line constructed as first class railway. The transportation performance of the narrow-gauge Bròd—Szarajevo main line exceeded significantly the performance of some standard gauge main lines of the Monarchy. The 25-30 km mean speed of the passenger trains running between Bròd and Sarajevo was the same as the European standard gauge main lines’ of the same length. The authorized speed of the BHOV 2-4-2 express locomotives, built in 1894-96, was 60 km/h, and they were the fastest narrow-gauge steam locomotives in the Monarchy and in Europe also at the time when they were put into service. The rack system of Abt mixed with adhesion service got wider use on the 135 km long line section which connected Sarajevo with Mostar via the Saint Ivan Pass.122 23 steam locomotives, built for mixed, rack and adhesion service, served the traffic on this line section in 1903. The extreme requirements demanded extreme technical solutions. It is just possible to characterise shortly the construction of the biggest European narrow-gauge railway network connected to the Boszna Railway. The construction of the fast developing network, which had the length more than 1000 km at the turn of the century, got the respect of the foreign professional experts for the engineers of the Monarchy. The success of the Bosnian-Herzegovinian network gave the impulse to build 760 mm gauge railways in wider range in the other regions of the Monarchy and also in Hungary after the turn of the century. The well proved technical solutions invented on the Bosnian-Herzegovinian network were used successfully by the narrow-gauge railways built in Hungary and in the other regions of the Monarchy.

121 The rigid wheel base of the 760 mm gauge, 0-6-2 wheel arrangement steam locomotives - designed in the Krauss Locomotive Factory, Linz - was 900 mm. The axle of the running wheel set, installed under the firebox, was joined to the third coupled axle by Krauss-Helmholz bogie, so the locomotives could run safety in the track curves of 60 m radii. The authorised speed of them was 35 km/h. The wide section of the main frame under the firebox made possible the application of large grate area. The indicated power of them was 217.8 HP (165 kW) firing with high quality coal. They run with trains of 515 t load on flat tracks and of 90 t load at 20 km/h speed on 20 ‰ gradients.

122 The Abt system consisted of two or three involute toothed vertical bars installed in the centre line of the adhesion track. The cog wheels of the gearing were in permanent connection with the toothed bars displaced horizontally to each other ensuring higher value of the contact ratio, therefore the running of the trains was smoother.
3.2 The Golden Age of the Narrow-gauge Steam Locomotive Production in Hungary (1906 - 4 July 1920)

3.2.1 The Development of the Narrow-gauge Railway Networks in Hungary and in the Austro-Hungarian Monarchy between 1906 and 4 July 1920.

Having prevented the bankruptcy the common burden sharing was introduced in the contracts for the construction of local railways supported by the Hungarian Parliament instead of the guaranteed interests independent from the operational costs and incomes, in 1905, which forced the contractors to build the new local railways with narrow-gauge.\textsuperscript{123} The Royal Hungarian Minister of Commerce, authorised for the right by under the section 3 of the Act XXXI of 1880 to determine the rules for the construction the equipment and the operation of local railways, regulated the construction of the narrow-gauge railways in the Departmental Order No. 52777 published on 21 November 1906.\textsuperscript{124} The Hungarian Government prepared a draft bill for the regulation of the inferior railways in 1907.\textsuperscript{125} Also the narrow-gauge network of the MÁV enlarged significantly in this period. The MÁV took over the Szatmár-Erdődi, Szatmár—Bikszádi, Segesvár—Szentágotai and the Gyulavidéki Local Railways in the beginning, which were constructed earlier by private initiative but the companies did not have the staff for the operation and maintenance of the lines. Later the Torda—Topánfalva—Abrudbányai and Marostordai Local Railways were third class narrow-gauge railways built already to MÁV Standards. The passenger trains ran by 30 km/h top speed on the narrow-gauge railways operated by MÁV and were equipped with vacuum brake and steam heating on some lines. The length of the third class railways operated by MÁV was 650 km in 1917, comparing to the more than 700 km length of the private narrow-gauge railways opened for public or limited public transport. The length of the steam operated narrow-gauge industrial railways was 2500 km and 112 km of the electrified lines. 354 km long portable field railways and 2800 km long narrow-gauge industrial railways operated by horse traction or manually were used in the Countries of the Hungarian Holy Crown.\textsuperscript{126}

The enlarging of the 760 mm gauge Bosnia-Herzegovina network, built in in the last two decades of the nineteenth century, was continued. The dual aim of enlarging of the network and increasing of its traffic was very important in the economic policy of the common Austro-Hungarian governments ruling the province after the turn of the century. This was supported also

\textsuperscript{123} The Contracts of Guaranteed Interest ensured fixed interest for the contractors upon their investment costs independent from the traffic and the incomes of the railways. The Act XXXI. of 1880 obliged the MÁV and the Act IV. of 1888 already the private local railways companies, enjoying the interest guaranteed by the State, to finance the operational costs of their lines connected to the main lines. The Standard Contracts invented from 1884 helped the construction of the local railway network significantly in the Countries of the Hungarian Holy Crown. The contracts contained further preferences but requested the use of MÁV Standards at the construction of the tracks, buildings and traffic equipment and the application of MÁV Regulations at the operation of the railways. The staff operated the local railways belonged to the MÁV. — Zelovich Kornél: \textit{A magyar vasutak története (The History of the Hungarian Railways – in Hungarian)}, Különnyomat: A magyar közlekedés monográfiaja, Budapest, 1925.

\textsuperscript{124} After closing the Ministry of Public Works and Transport on 15 June 1889 the supervision of the railways was the duty of the Ministry of Commerce led by Baross Gábor. — Mezei István szerkesztő. \textit{A Magyar vasút krónikája a XIX. Században (The Chronic of the Hungarian Railway in the Nineteenth Century – in Hungarian)}, Budapest, MÁV Zrt. Vezérigazgatóság, Budapest, 2009, p. 282

\textsuperscript{125} The Draft Bill, like the Act passed in Prussia already in 1892, classified all the railways excluding the national main lines as inferior railway, including the local, farm, light and private railways operated in the Countries of the Hungarian Holy Crown, independent from their gauge. The primary aim of it was to avoid the construction of local railways built with weak track superstructure, which decreased the efficiency of the main line network. It would have preferred the construction of narrow gauge railways on the routes of weak traffic at the same time, but it was never presented for discussion to the Parliament. — \textit{Az alsóbbrendű vasutakról szóló törvény tervezete (Draft Bill for the Regulation of the Inferior Railways – in Hungarian)}, Budapest Atheneum, 1909

\textsuperscript{126} (Transportation Yearbook, 1917 – in Hungarian) Mór szerkesztő: \textit{Közlekedési évkönyv az 1917. évről, Wodianer és fiái, Budapest, 1918}
by the Hungarian Parliament because the enlarged network and the rising traffic requested new rolling stock and gave a lot of work and increased the incomes of the domestic locomotive factories suffering of the lack of orders. The goods transported to the sea side increased the traffic of the Adriatic ports and helped the fast-developing Hungarian foreign trade connections by offering a second railway connection to the sea side.

This dual aim was served by the construction of the 167 km long line running from Sarajevo to the Serbian border at Vardiste via Visegrad, placed into service on 1 July of 1906. At the same time the Monarchy inspired Serbia to build a 760 mm gauge line started at Stalac station of the Beograd—Nis Railway to the Bosnian border instead of the construction of the Adriatic connection through the territory of the Turkish Empire. The Monarchy made an agreement with Serbia to connect the Stalac—Vardiste line with the Bosnian network in 1907. The 167 km long Stalac—Uzice section of the West-Serbian Railway was finished in 1912. The construction works were stopped on the Serbian side because of the difficulties with the lie of the land. After the occupation of Serbia in October of 1915, the Monarchy continued the construction of the missing nearly 60 km long link of the railways on the 9 km long section from Vardiste to the foot of the Sargan Mountain, in 1916, which became very important also from the strategic point of view. The construction works was finished after the earth fall happened during the drilling of the tunnel under the Budim Mountain, in which 200 Italian and Russian prisoners of war were died.

3.2.2 The Development and the Standardisation of the Narrow-Gauge Steam Locomotive Production

3.2.2.1 Locomotive Manufacturers and their Steam Engines

MÁV Machine Factory, Budapest

The design and manufacture of the standard type narrow-gauge locomotives, started at the end of the previous period, were continued in the MÁV Machine Factory. The construction and the successful putting into service of the first type 70 locomotives was followed by the production of the first units of the type 75 in 1906, the types 78, 79 and 85 in 1908, the type 86 in 1909, the type 94 in 1910, the type 99 in 1911 and last but not least the types 106 and 107 in 1916.

Besides the production of the standard types the Factory did not rejected the orders for the industrial locomotives of special requirements. The type 81, 96 and 100 locomotives built for the Bosnia-Herzegoivan lines on Austrian design represented a special group in the products of the factory.

Standardised Type Narrow-gauge Steam Locomotives of the MÁV Machine Factory

Several new locomotive types of 2.67-4.4 t axle load with 30, 40, 50, 60, 80 and 90 HP (22, 29, 37, 44, 59 and 66 kW) power capacity were designed and built in the MÁV Machine Factory for the narrow-gauge railways between 1906 and 1920. The type 70 locomotives closed the standardised narrow-gauge locomotive offer of the Factory, which were built with 0-8-0 wheel arrangement and 150 HP (110 kW) output for the lines of 5.5 t axle load. The type 75, 78, 79, 86, 99, 106 and 107 steam locomotives had 0-6-0 wheel arrangement and 30-80 HP (22-59 kW) output. The type 94 and 85 of 60 HP (44 kW) and 90 HP (66 kW) output were built with 0-8-0 wheel arrangement. The boilers of each type were designed for coal and wood firing, but the wood fired version of the type 107 locomotives were the type 106s. Also, the different gauges of the narrow-gauge lines were taken into consideration at the design period widening the possible territory of operation for the locomotives. The type of 75, 79, 86 and 99 locomotives were built also with 600, 700, 950 and 1000 mm gauge besides the 760 mm gauge versions.
Fig. 10. The 0-6-0 tank engine of the MAV Machine Factory Type 75, 1906.

Fig. 11. Type 85 steam locomotive of the MAV Machine Factory, still in operation, built with wheel arrangement 0-8-0 from 1908. (Photo: Malatinszky Sándor)

The Annex 8 contains the technical characteristics of the standardised narrow-gauge steam locomotives of the MAV Machine Factory.
Industrial Railway Locomotives

Although the demand for the miscellaneous industrial locomotives decreased in the production of MÁV Machine Factory, because of the introduction of electric traction on the network of the mine and industrial railways and standardised type steam locomotives were built in large number, but the MÁV Machine Factory built its most powerful 1000 mm gauge industrial locomotives of types 98 and 112. The engines were built for the Perecesi Mine Railway and for the service of the new Siemens-Martin furnaces of the Magyar Királyi Vas és Acélgyár (Hungarian Royal Iron and Steel Factory Diósgyőr) in this period.

Type 98 steam locomotives

The locomotives of type 98 of the MÁV Machine Factory were the metre gauge version of type 51, but the grate area of the firebox was enlarged to 1.1 m² and the boiler pressure was increased to 14 bars as of the type 69. The indicated power of the locomotives was 200 LE-t (147 kW), resulted from the calculation based on the specific load of the grate area firing with MÁV Standard Coal using the formulas 3.1 and 3.2, of the Annex 3. Only two units were built of the type 0-8-0 tank engines equipped with Klien-Lindner axles in 1912. The type 98s was the heaviest locomotives constructed by MÁV machine Factory for 1000 gauge with 26 t service weight and 8750 mm length over buffers.

Type 112 steam locomotives

The MÁV Machine Factory delivered three type 112 locomotives for the order of the Diósgyőr Iron Factory in 1915. The main technical characteristics of the 0-8-0 metre gauge tank engines, put into service on the Factory’s network, the diameter and the stroke of the piston, the diameter of coupled wheels, the service weight, the axle load and the boiler pressure were the same as of type 98 locomotives. The grate area and also the heating surface were nearly the same, so the power of the locomotives was similar, but the engines put into service with No 8, 9, and 15 were shorter by 2000 mm. Their wheel base was only 2750 mm compared to the 4000 mm of type 98’s. Because of shorter dimensions the nearly the same heating service of the boiler of the type 112 locomotives was ensured by 161 smoke tubes of 40 mm diameter and 2300 mm length. The new locomotives ran safety with their Klien-Lindner axles on the Factory’s network built with small curve radii.

Fig. 12. Metre gauge steam engine Type 112 of the MÁV Machine Factory, 1915

The Annex 5 contains the technical characteristics of the narrow-gauge industrial steam locomotives of the MÁV Machine Factory type 98 and 112.
Narrow-gauge Locomotives Built for the BHOV

Type 82 steam locomotives
The extensions of the BHOV network from Sarajevo to the sea port Gravosa near the today’s Dubrovnik via the Dinar Mountains, and to the Turkish and to the Serbian borders, were constructed on difficult lie of the land. The new lines were built with many tunnels and 20-25 % inclines. New Klose system 0-10-0 tank locomotives were designed for servicing the increased freight, but instead of the complicated steam locomotives, new compound engines of 0-8-2 wheel arrangement, type IVa5 1000ff and designed by also the Krauss Locomotive Factory Linz, were put into service from 1903. The new locomotives were equipped with sliding axle patented by Karl Gölsdorf⁴⁷, and run in the curves of radii 70 m safety.⁴⁸ The authorised speed of the engines was only 35 km/h despite the 900 mm diameter of their coupled wheels, compared to the 40 km speed of the Klose-system locomotives. Carriage warming valve and Hardy type vacuum brake, applied on the trains running on the BHOV network, were also installed on the new locomotives meeting the requirements of the passenger and mixed train service. The locomotives ran with four wheeled tenders of 3 t coal and 7.5 m³ water loading capacity. The water tank of the tenders was equipped with floating water gauge indicator. The locomotives were equipped also with auxiliary oil firing device, taking into consideration the service in the long tunnels. Five units were built as type 82 of the typically Austrian designed locomotives by the MÁV Machine Factory in Budapest, in 1908.

**Fig. 13. Steam engine Type 82 of the MAV Machine Factory, 1908**

Type 96 steam locomotives
The company, which were operated the large network of the BHOV, decided to continue the procurement of the class IVa5 locomotives with the superheated simple version of the type IVa5 1000ff compound engines from 1909, based on the results of the locomotive running tests carried out on the 760 mm gauge lines of the Mariazellerbahn in Austria.⁴⁹ The two versions of the class IVa5 were the same excluding the boilers and the engines. The superheated two-

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⁴⁷ The axle journals of the sliding axles invented by Karl Gölsdorf was longer than of the normal axles fixed to the frames according to the requested clearance for negotiating the curves, So the sliding axles could move transversely in the axle boxes decreasing the rigid wheel base of the trains significantly. — Malatinszky Sándor: *A MÁV állagába besorolt legnagyobb teljesítménnyű, keskeny nyomtávolságú steam locomotiveok (The Most Powerful Narrow-gauge Steam Locomotives of the MAV Tractive Stock – in Hungarian)*, Budapest, Vasútgépészeti, 2001/4, p. 3-9.

⁴⁸ The wheels and the wheelsets are guided on the tracks by the friction arose between the wheel rim and the rail, the conicity of the wheel rim and the wheel flange. The wheel flange reaches the rails rarely for a short time on the strait tracks in ideal cases, but in the curves, it guides the wheelsets. The smallest curve radius to negotiate is determined by the construction of the vehicle and the running gear. Running in a smaller curve radius the vehicle gets tightened or the wheel flange climbs up the rail head and the vehicle get derailed. The aim of the invention of the different system axles and bogies for negotiating the small curve radii was also the reduction of the rolling resistance of the vehicles in the curves.

⁴⁹ The superheated simple and compound versions of the same type high power locomotives were put into service on the Marizellerbahn as class Mh and Mv to compare the operation of the engines, in 1906.
cylinder version of the class IVa5 locomotives, redesigned in the Linz Locomotive Factory as type IVa5 1100ff, had piston valves. The tractive effort of the locomotives, built with 430 mm diameter pistons, was higher with 6 kN in spite of the lower boiler pressure which was decreased from 15 to 12 bars compared to the compound version. The power of the locomotives was 650 HP (478 kW) in case of firing with high quality coal, ranking them as one of the most powerful engines running on the 760 mm gauge lines in the beginning of the century.

The carriage warming valve makes them possible for the passenger service, but because of the 35 km/h authorised speed they run eighth freight trains mainly. The BHOV and later the JZ put into service express locomotives for passenger service running by 50-60 km/h on the narrow-gauge lines. The MÁV Machine Factory started the production of the locomotives as type 96 in 1911 and built 12 units in four batches until 1916.

The Annex 9 contains the detailed technical descriptions of the type 82 and 96 narrow-gauge steam locomotives and the power calculation of type 96 locomotives.

Type 100 steam locomotives
The MÁV Machine Factory built eight 2-6-2 express engines for the 760 mm gauge lies of the BHOV between 1911 and 1913. The locomotives were designed by the Krauss Locomotive Factory in Linz with outer main frame and 1080 mm diameter of coupled wheels which was very unusual for the 760 mm gauge locomotives at that time. The balance weights of the running gear were fastened outside with the cranks. The boiler pressure was 12 bars according to the requirement of the superheated two cylinder engines. The specific steam production of the boiler, calculated from the 1.5 m² grate area, was 63.38 kg/m²h in case of firing manually with high quality coal. This value was higher than the applied in case of the standard gauge express locomotives. The locomotives had relative small, 370 mm diameter pistons, but their more than 600 HP (441.6 kW) calculated effective power was in harmony with the indicated power of the boiler. The authorised speed of the locomotives was 50 km/h. The BHOV put into service 23 class IIIb5 locomotives, 15 of which were built by the Krauss Locomotive Factory in Linz.

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transported to the sea side increased also the traffic of the Adriatic ports and helped the widening of the Hungarian foreign trade connections began to fast development. (Thesis 7.)

Miscellaneous Narrow-gauge Steam Locomotives

Steam Locomotives of the Military Railways and Military Field Railways

The preparation of the successful military operation in 1915, and the operation of the railways on the occupied territories also for public and military services made new requirements for the Imperial and Royal Railway Regiment working with Korneuburg centre in Austria. The military organisation set up in 1873 reached important successes in the construction and operation of the 450 km long 760 mm gauge Bosna Railway which connected the Slavonian Bród with Sarajevo and the 100 km long standard gauge Banja Luka—Doberlin Military Railway. The army troops set up for the construction and operation of military railways were not able to operate the large networks on the large occupied territories and the invention of the unified railway direction was necessary. Also, the preparation and the concentrated execution of the military transportations on the 45 000 km. long standard and 2 520 km long narrow-gauge network Monarchy operated with 285 000 locations, stations and depots on the Austrian and 160 000 on the Hungarian territory requested a new organisation. On the galling experiences of the first year of the war, the Central Railway and Shipping Transportation Directorate was subordinated under the direct destination of the Chief of the General Staff of the Military Railways belonged to the War Ministry, enlarging its activity to the supervision of the public transportation, on 27 July 1915.131

Besides the railways used for public transportation service in the peaceful times, the Army of the Monarchy put into battle order portable narrow-gauge railways to serve the fighting troops and the heavy guns on the war fields. The Military Field Railways could be laid down easy and transported munitions and reserves from the safe depots for the troops fighting in the front lines and turned back with wounded soldiers. The rolling stock of the Military Field Railways was transported on heavy carts to the war fields. The military railways had different 600-700, or 800 mm gauges than the public railways according to the military transportation demands.132 The locomotives constructed and built for the service of the portable military railways, first of all used for the support of the fighting troops, were not able for the public transportation without

131 The Central Transportation Directorate supervised the Military Transportation Directorates of which the Public Railway Offices were subordinated to. The Military Railways directed the railways of occupied territories including the military transportations. The increasing transportation demands requested new rolling stock and new transportation routes frequently, especially on the occupied territories. The stations and depots of the Military Railways were operated by the qualified staff enlisted for the military service from the Railway Companies of the Monarchy and the most part of the locomotives arrived from the Railways of the Monarchy which ran on the networks of the Military Railways. The Military Railways operated large narrow-gauge networks besides the standard gauge lines on the occupied territories. The South Military Railway operated 527 km long network on the occupied Serbian territory of which 390 km was 760 mm gauge.

The MÁV Military Directorate put into service 149 steam locomotives on the networks operated by the Military Railways with the numbers of 324,901-995, 342,901-944, and 442,901-910. The locomotives were equiped also with automatic Hardy vacuum brake.

The MÁV placed at the Military Railways’ disposal eleven type 70 narrow gauge locomotives built by the MÁV Machine Factory of No 490,951-961, fifteen type 85 locomotives of No 492,951-965 besides the standard gauge locomotives. Only eight of the class 490 locomotives were newly built. Further three type 78 and three type 106 locomotives were put into service built by MÁV Machine Factory. — Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1915-től 1944-ig. Budapest, MÁV Rt. 1997, A vontatójárművek fejlődése 1915-1944 között (The History of Hungarian Railways between from 1915 to 1944 – The Development of Tractive Stock between 1915 and 1944 – in Hungarian, p. 251-262.

132 The duty of the 600-700 mm gauge Military Field Railways was to serve the heavy guns set up close to the front lines, the transportation of munition and reserves for the fighting troops and the insured soldiers to safer places.
modifications. They were built with low axle load and 0-6-0 or 0-8-0 wheel arrangement to ensure the high tractive effort. They could run safety in 20 m radius track curves and on 100 % slopes because of their short wheel base and the special construction of the boilers. The Military Field Railways used also tractors equipped benzol motors and battery locomotives in increasing number beside the steam engines, but electrified lines were used on the Italian front as well.

The general military mobilization, ordered on the territory of Austro-Hungarian Monarchy on 25 July 1914, did not make any plus demands for the third-class railways operated in the countries of the Hungarian Holy Crown in the beginning. Having driven the Russian troops back intruded in the Sub Carpathian region in 1915, more and more new Military Railway lines were built in the valleys of the Carpathians. Some of them were connected to the existed narrow-gauge lines or networks. These railways played important role in the transportation of munitions and reserves for the troops fighting on the occupied territories and in the preparation of the successful military actions of the Monarchy’s Army in Galicia. The Army of the Monarchy endeavoured to fulfil the military transportation demands by the rolling stock belonged to stock of the regiments of the Imperial and Royal Railway Army. The unexpected transportation demands arisen frequently made necessary to use the rolling stock of the public and industrial narrow-gauge railways in a shorter or longer run as well. The wide spread and use of the 760 mm gauge lines in the public and industrial transportation contributed to the military success of the Monarchy significantly.

The MÁV Machine Factory constructed and built many steam locomotives of types 60, 67 and 83 for the order of the Imperial and Royal War Ministry from 1902, but the largest batch of the 25 type 121 locomotives was put into service beyond the front lines in 1917 and 1918. The 600 mm gauge locomotives of 0-6-0 wheel arrangement were designed by the MÁV Machine Factory. The standardised 70 and 85 type locomotives appeared in the stock of the Military Railways in 1915, and the types of 106 and 107 engines in 1916 as well.\(^\text{133}\)

![Fig. 15. The locomotive of standardised Type 106 of the MÁV Machine Factory which met the requirements of the Military Railways as well. 1916](image)

The Annex 5 contains the detailed technical data of the miscellaneous narrow-gauge steam locomotives designed and built for the Military Railways and Military Field Railways by the MÁV Machine Factory.

\(^\text{133}\) Pottyondy Tihamér: *A Magyar Államvasutak mozdonyparkja, mozdonyaínek szerkezeti fejlődése és a modern mozdonytípusok (The Locomotive Stock of the Hungarian State Railways, the Development of the Locomotive Construction and the Modern Locomotive Types – in Hungarian)*, A Magyar Államvasutak Gépészeti Közlései, Budapest, 1918 november
3.2.2 Railways and Industrial Railway Workshops

Workshop of the Rimamurány Salgótarjáni Ironworks Co., Ózd

The Rimamurány Salgótarjáni ironworks Co. set the centre of the rude iron production to the Ózd and put into service the new blast furnaces in 1908, which made necessary to enlarge the Factory’s industrial railway network. In parallel with the building of the furnaces the construction of the new standard gauge Abt system rack railway for the dross transportation, which ran from the Factory to the Lower Slag Tip, was finished in 1906. The 17 km length of the Factory’s standard gauge network exceeded the length of the metre gauge lines operated in the Ózd region in 1910. The coal transportation began from the Farkaslyuk Colliery on the siding connector to the upper end of the rack railway in 1918. A new metre gauge steam locomotive was built for the traffic increased on the Ózd—Nádasdi Railway. The locomotive called „Járdánháza” was identical with the steam engines of 0-6-0 wheel arrangement running on the Railway, and was put into service in 1907.

The Annex 7 contains the detailed technical data of the narrow-gauge steam locomotives built by the Railway Workshops of the Rimamurány Salgótarjáni Ironworks Co.

3.2.3 The Inventions and Innovations on the Narrow-gauge Steam Locomotives

A compound 0-8-0 narrow-gauge engine was designed in the MÁV Machine Factory in 1914. Although the MÁV Machine Factory built Austrian design narrow-gauge compound steam locomotives for the BHOV, all of the narrow-gauge locomotives designed and built in Budapest, except the types 66, were simple engines. The use of Schmidt type super heaters became general on the new locomotives after the beginning of the WWI, except the low power capacity narrow-gauge engines. Having pushed into the background of the compound engines new superheated dual versions of the locomotives appeared including the high power capacity narrow-gauge locomotives as well. The better balanced dual engines widened the scope of the employment of the formal goods locomotives to the passenger service. The MÁV ordered almost all of the new steam locomotives with Brotan boilers during the WWI to save the copper for the military utilisation. In order to prevent the damages experienced frequently on the Brotan boilers and to slow down the fouling in the Brotan tubes feed water cleaners were installed on the MÁV locomotives. The Brotan boilers were not installed but the feed water cleaners were widely used also on the narrow-gauge locomotives making good influence on the operation of the boilers. The MÁV ordered the new narrow-gauge locomotives equipped with standardised type feed water cleaners system Petz-Rejtő from the MÁV Machine Factory. The steam locomotive production nearly doubled in the MÁV Machine Factory in the years of WWI compared to the remarkable production of the millennium year 1896. Although the Factory produced 307 new locomotives in 1906 but its capacity was not enough to fulfil the demands of the MÁV increased by the military transportation. Therefore, the MÁV Headquarters ordered the significant part of the new class 328 and 342 locomotives from the Henschel Co. in Kassel.

134 Only the tube plate was made of copper on the boilers built with Brotan system water tube firebox. The MÁV had a unique locomotive stock of steel firebox consisted of more than 800 Brotan boilered steam engines at the end of the WWI. Because of the wide spread of the Brotan boilers also the use of the feed water cleaners became general. The cleaners slowed down the fouling in the Brotan boilers and decreased the frequency of the damages of the Brotan water tubes caused by the overheating because of the scale. To prevent the damages experienced frequently on the Brotan boilers and to tubes feed water cleaners.

135 143 class 342 locomotives were built by the MÁV Machine Factory and 153 by the Henschel Co. for the order of the MÁV between 1915 and 1919. 56 class 328 express locomotives were built by the MÁV Machine Factory in Budapest between 1920-22 and 100 were built by the Henschel Co. in Kassel in 1920. 17 of the locomotives were taken over by the new Czech-Slovakian successor state. — Dr. Kovács László főszerkesztő: Magyar Vasútörténet 1915-től 1944-ig A vontatójárművek fejlődése 1915-1944 között (The History of Hungarian Railways between from 1915 to 1944 – The Development of Tractive Stock between 1915 and 1944 – in Hungarian, Budapest, MÁV Rt. 1997. p. 254-256.
3.2.4 The Place and the Role of the Hungarian Narrow-gauge Steam Locomotive Production in the Austro-Hungarian Monarchy

The MÁV Machine Factory, as one of the Hungarian locomotive manufacturers, offered and built locomotives of its own design for the Hungarian railway companies even from the second part of the 1870s, when the steam locomotives, running on the Hungarian network were produced mainly by Austrian and German builders. The reasons for the construction of Hungarian types were the special operation and traffic conditions and the experiences gained by running the foreign types. The railway companies recognised soon, the economical operation of the railways is possible only when the construction of the locomotives, forwarding the trains, met the requirements of the given track and traffic conditions. Replacing of the expansive raw materials, the unknown production technologies or also the high costs could lead to the domestic production. The quality of the cheap fuels and the feed water determined also the construction of the locomotives. The standardisation became more and more important as the networks were enlarged, not only because of the spare parts, but the general use of the locomotives in the different traffic conditions.

The Hungarian narrow-gauge steam locomotive production was characterised by a strange dualism until the turn of the XIX/XX centuries. The MÁV Machine Factory built its own designed locomotive types from 1876, but the Hungarian railway companies ordered the same Austrian or German type locomotives frequently to enlarge their locomotive stock as they put into service earlier.

Comparing the examined periods, the rate of the narrow-gauge locomotives built by the MÁV Machine Factory increased to 64.5 % between 1906 and 1920 against the 55.6 % of the previous period from 1873 to 1905. The number of the foreign designed types were six in both periods, but the number of the own designed types decreased from 19 to 16, while the number of the narrow-gauge locomotives built in Budapest increased from 50 to 374. The rate of the narrow-gauge locomotives in the total production increased from nearly 3 % to almost 16 %.

The MÁV Machine Factory designed and built narrow-gauge locomotives different from the types of the other locomotive works in the Monarchy after the turn of the century, locomotives, which met the special requirement of the Hungarian railway traffic.

One of the reasons for the success of the locomotives was the rate of the grate area and the boiler heating surface based on firing low quality fuel, like wood, in most cases. Therefore, the locomotives could be overloaded on the request of the traffic conditions in case of firing of quality coal. The use of Klien-Lindner axles made possible the application of 0-8-0 wheel arrangement providing higher tractive effort without increasing the axle load and reconstructing the small curve radii of the tracks. Taking into consideration the running on the 60 ‰ and in some cases on the 100 ‰ slopes at the boiler constructions widened the use of the locomotives from the local networks to the forest and industrial railways and also to the military railways during the WW1.

The MÁV Machine Factory – later the MÁVAG Budapest works – settled in the production of the narrow-gauge locomotives meeting the requirements of the 760 mm gauge railways built in the Carpathian Basin and in the successor states of the Monarchy. Its own designed locomotives had special Hungarian character in comparison the steam engines built by the other locomotive manufacturers in the Austro-Hungarian Monarchy. (Thesis 8)
3.3 Between the World Wars

The confirmation of the Peace Dictate, in the Trianon Palace of Paris on 4 July 1920, set the false illusions at rest, which hoped taking back the occupied territories and the peaceful reposi-
tion of the 1000 years old Hungarian borders trusting in the European cultural nations of the triumphant world powers. The confirmation and the separation of the occupied territories had broken the organic railway network operated in the Countries of the Hungarian Holy Crown which was developed and constructed for 70 years. The two-third of it, lying on the occupied territories, was taken over by the successor states. All of the narrow-gauge lines operated by the MÁV were on the occupied territories except the short section of the 760 mm gauge Gyulavidéki Local Railway, which remained inside the Trianon borders. **Having separated the MÁV tractive stock, only five narrow-gauge steam locomotives of the 112 remained still in MÁV operation,** which were used mainly at the earthworks of the standard gauge track corrections. Only the narrow-gauge public network of the AEGV, the Nyíregyházavidéki Kisvasutak (NyvKv) and most part of the network of the Bodrogközi Gazdasági Vasutak (BkGV) excluding the Zemplénagárd—Királyhelmeć section remained beyond the Trianon borders. The most and more valuable parts of the well-known Hungarian mineral resources were on the separated territories taken over by the successor states. Only 37 of the 176 narrow-gauge industrial steam railways remained under Hungarian control. The length of its network decreased from 2500 km to 343 km. The half of the 26 electrified industrial railways and 40 % of the industrial railways of horse traction and the portable field railways remained outside of the Trianon borders. **The narrow-gauge railways played very important role in the revitalisation of Hungary’s economic life, which was the most important task after the confirmation of the Trianon Peace Dictate.**

3.3.1 The Development of the Narrow-gauge Railway Network in Hungary in the Time Period between the 5th July 1920 and the First Vienna Decision

The Management of the MÁV and the Hungarian governments of the inter-war years consid-
ered the protection of the Hungarian industry as prime necessity. The increased mining of the mineral resources and timbering of the forests remained inside the Trianon borders made ne-
cessary to develop the network of the privately used mine and forest railways. The loss of the good quality mineral resources encouraged the factories and industrial plants for the better utilisation of the raw materials. The excavation of the new sites requested also new routes of transportation. **The factories of the rolling stock industry remaining inside of the new borders lost their markets and offered a good possibility for the development of the narrow-gauge network.**

The 760 mm gauge network of the Szinvavölgyi Erdei Vasút (Szinvavölgyi Forest Railway - SzVEV) was constructed in the 1920s to utilise the timber of the Diósgyőr State Forest Estate lying in the Bükk Mountains. The lengthening of the network of the Mátra Vasút (Mátra Railway – MV) near the city of Gyöngyös followed it, and the opening of the Hegyközi Vasút (HV) and the forest railways of the Börzsöny and Sőttő Archbishop Estates. New forest railways were built in the west, on the Trans-Danube country side in the Bakony Mountains and on the hills of County Zala. New mine railways were built between Bodajk and Balinka to carry the coal from the Kisgyőn and Balinka Collieries and between Balinka and Gánt to transport the bauxite. The 14 km long metre gauge mine railway, transporting the ore from the Rudabánya iron ore fields, was converted to a standard gauge industrial siding in 1925. The fast construction of the road network increased the demand for the stone giving more and more work for the narrow-
gauge railways serving the stone quarries. Steam operated forest railway was built in Visegrád and quarry railways were constructed in Somoskőújfalu and in the Bükk Mountains to carry the stone. Having recognised its importance, the passenger service was introduced on some forest and mine railways in the 1920 as well. The absence of the draught animals after the WWI and the increase of the sugar exports made a good influence on the development of narrow-gauge farm railways’ network.

The economic crisis of the post war years hindered the further enlargement of the secondary railway network according to the public transportation demands. Therefore the construction of the new third class narrow-gauge railways came into view again. Despite the economic difficulties inside of the Trianon borders, the expansion of the farm railway network, opened for limited public transport, was continued. The AEGV enlarged its network with the new Kaszaper—Orosháza and Orosháza—Gyopárosfürdő lines. New narrow-gauge farm railways, opened for limited public transportation, were built for the transportation of agricultural goods and timber produced on the farm lands surrounding the cities of Cegléd, Szeged and Kecskemét. In 1927, the 67 km long network of the Szegedi Gazdasági Vasút (Szeged Farm Railway - SzGV), the Cegléd—Vezeny line of the Ceglédi Gazdasági Vasút (Cegléd Farm Railway - CGV) and the Sárospatak—Sátoraljaújhely extension of the BkGV were opened. In 1928 started the scheduled service on the Kecskemét Rávágy tér—Kiskunmajsa and the Bugacmonostor—Alsó-Monostori téglaégető lines of the Kecskeméti Gazdasági Vasút (Kecskemét Farm Railway - KGV). The motorization of the narrow-gauge railways was getting on fast, as well. The CGV and the SzGV run only diesel locomotives and diesel railcars both in passenger and freight service, already in the 1930s. Also the 950 mm gauge line of the Debreceni Erdei Vasút (Debecceni Forest Railway - DVEV) was extended and the limited public transportation was introduced. The largest narrow-gauge network of the inter-war years opened for limited public transportation was created by opening the new bridge crossing the river Tisza at Balsa in 1936. The new bridge connected the networks of the NyvKv and BkGV which had also connection with the HV at Sátoraljaújhely. The express train service was also introduced between the two shire-towns Nyíregyháza and Sátoraljaújhely. Rail buses were put into operation from 1936, which run at 60 km/h in scheduled service on the tracks built with week superstructure of the NyvKv and the BkGV. The narrow-gauge forest, farm and industrial railways played determinative role in the recovery of the Hungarian economic life in the 1920s.

The Hungarian narrow-gauge railway network was expanded in the years after the WWI while the length of the narrow-gauge networks of the world including the surrounding countries, except the newly established Serbian-Croatian-Slovenian state, was decreased.

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138 Csohák László: A Debreceni Erdei Vasút 80 éve (80 Years of the Debreceni Forest Railway – in Hungarian), Közlekedéstudományi szemle, 12/12 1962, p. 567-563.
3.3.2 Development of the Narrow-gauge Steam Locomotive Production

3.3.2.1 MÁVAG139, Budapest

More than twenty one percent of the 574 steam locomotives built in Budapest between 1921 and 1938 were narrow-gauge. 123 units, nearly the two thirds of the narrow-gauge steam engines manufactured in this period, were put into service on the Yugoslavian 760 mm gauge network.140

New drafts of narrow-gauge steam locomotives were designed by the Construction Department of the Budapest MÁVAG works between the world wars. A superheated 750 mm gauge, 0-6-0 tender locomotive, which was never built, the successful type 128 locomotives designed and built for the Yugoslavian 760 mm gauge network, and the type 127 locomotive were among them. The type 128 locomotives were the most powerful narrow-gauge steam engines designed and ever built in Budapest. The type 127 locomotive was equipped with air brake, the same boiler and running gear as of type 70 locomotives.

Standard Type Narrow-gauge Steam Locomotives

The traffic of the public farm railways running on the Great Hungarian Plain – except the KGV - did not require more powerful locomotives than 50-80 HP (36–59 kW) output.141 In this period, new built type 70 locomotives were put into service only on the steam operated industrial railway of the Aluminium Ércbánya és Ipari Rt. (Aluminium Ore Mine and Industry Co.). The 760 mm gauge railway ran to the Bodajk station of the Duna Száva Adria (DSA) railway’s Székesfehérvár—Komárom line 12 km away from the Company’s bauxite mines in Gánt.142 143 Taking into consideration the inconstant and the special transportation demands - that the locomotives hauled only empty wagons uphill to the mines - most of the new locomotives put into service on narrow-gauge mine, forest and industrial railways were steam engines of low power capacity, except the Balinka colliery railway, the Somoskőújfalu quarry railway, the industrial railway of the Archbishop’s Gerecse Forest Estate and the HV, KGV, LÁEV and SzGV opened for public service. The campaign traffics of the estate and sugar cane factories railways were served also by steam engines of low capacity. In this period - between 5th July 1920 and the First Vienna Decision - the MÁVAG Budapest works built new steam engines of low power capacity with 0-6-0 wheel arrangement, type 79, 99 and 106 with some exceptions for the domestic narrow-gauge railways.

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139 The Ministry of Finance took over the supervision of the MÁV Machine Factory and the Diósgyőr Iron Factory from the Ministry of Trade in 1922. The two factories operating under common management got the name Magyar Királyi Állami Vas- Acél- és Gépgyárak (Hungarian Royal State Iron Steel and Machine Factories - MÁVAG).

140 M. Kir. Államvasutak Gépgyárán Mozdony és szerkocsi jellegezés (Identification of Locomotives and Tenders - in Hungarian), Ganz-Archív

141 The 760 mm gauge Kecskemét—Kiskunmajsza line of the KGV was technically suitable for the transportation of standard gauge wagons on special underframes in contrast with the practice of reloading on the Hungarian narrow-gauge railways. The low costs of reloading hindered the wider use of this special mode of transportation.

142 Having nationalised the DSA company MÁV took over the operation of the Székesfehérvár—Komárom line in 1932.

143 The railway had a big marshalling yard in Gánt and were operated according to the seasonal mining of the open cuts at the beginning and later continuously. Characterising its transportation performance: in 1932 the railway carried 425 000 t bauxite to the Bodajk MAV station twelve km away from the mines.
Type 127 steam locomotives
The public transportation started on the 56 km long, 760 mm gauge Kecskemét Rávágytér—Bugacmonostor—Kiskunmajsa line of the KGV on the 17th September 1928. The railway was built for the utilisation of the land area and forests owned by the city of Kecskemét and the central territories of the Kiskunság which was avoided by the standard gauge lines. A 7 km long industrial siding, constructed earlier, joined to the Kecskemét—Kiskunmajsa line at Bugacmonostor station on which the timber cut in the forests of Bugac was carried to the Bugac brick works. The city council of Kecskemét bought three steam locomotives from the MÁVAG for servicing the traffic on the railway. The 0-8-0, type 85 and the 0-6-0, type 106 steam engines were considered as well known and well-tried products of the factory. The MÁVAG built a new 0-8-0 tender locomotive for the heavy freight and passenger service. The type 127 steam engine had 6.6 t axle loads and was a heavier version of the type 70 locomotives. The well tried high capacity boiler equipped with the feed water cleaners system Petz-Rejtő and the cylinders were the same. The diameter of the driving and coupled wheels was increased from 750 to 900 mm. The capacity of the water tank was larger by 1 m³. The main frame of the locomotive and also the central line of the boiler were higher because of the bigger wheel diameter. The modifications increased the empty weight of the locomotive by 2.7 t and the service weight by 4.4 t. The locomotive was equipped with two-cylinder air compressor and air brake. The 3450 kg tractive effort of the locomotive was nearly the same as the type 70 locomotives of 22 t service weight. The enlargement of the wheel diameter made possible to increase the permitted speed of the locomotive by 10 km/h. The Type 127 locomotive could haul as fast trains as with diesel traction, but the operation of the trains was cheaper by the diesel railcars and diesel locomotives put into service at the end of the 1920s. Only one unit of the Type was built.

Narrow-gauge Industrial Locomotives
The increase of the production of the Ózd and Diósgyőr steel works and the modernisation of the Borsodnádasd sheet-iron works made necessary also the development of the rolling stock of the mine and industrial railways, first of all to put into service new locomotives on the private railways serving the factories.

The MÁV Machine Factory built three type 112 steam locomotives for the metre gauge network of the Hungarian Royal Iron and Steel Factory Diósgyőr in 1920. The locomotives were built with narrow driver’s cab and could run without restrictions on the rails laid down inside the workshops. Putting into service the steam engines the building of miscellaneous narrow-gauge locomotives was finished in Budapest. The factory built only standard type locomotives for the order of industrial railways.

144 *Vasúti és Közlekedési közlöny* 59. évf. 93 szám, 1928. november 18.
145 One of the biggest Hungarian fruit market was in Kecskemét between the World Wars. 62 % of peach, 68 % of sour cherry and 80% of cucumber produced in Kecskemét and its surroundings were exported in 1937. The railway was built by English credit and could carry also standard gauge freight wagons making the unloading unnecessary at the connecting stations. Significant part of the exported agricultural products was carried by the KGV. — Dr. Kovács László főszerkesztő: Magyar Vasúttörténet 1915-től 1944-ig A vontatójárművek fejlődése 1915-1944 között (The History of Hungarian Railways between from 1915 to 1944 –The Development of Tractive Stock between 1915 and 1944 – in Hungarian). Budapest, MÁV Rt. 1997. p. 273.
146 The locomotive was converted to 0-6-2 wheel arrangement later, to increase the capacity of the water and coal tanks.
147 The KGV planned to put into service also the KKHB VI. 6026 (HB VIc 7) 2-6-0+0-6-0 Henschel compound locomotive built in 1916, but it was scrapped in 1928.
The 760 mm gauge locomotives built for the JDZ
The Trianon Peace Dictate obliged Hungary to pay also war reparations in addition to the hand-over of its territories. The Hungarian rolling stock manufacturers delivered new narrow-gauge steam locomotives, covered vans, open goods wagons and bogies for passenger carriages to the new born Serbian-Croatian-Slovenian State in addition to the hand over and repair of the former MÁV vehicles as war reparations. The MÁVAG built 113 steam locomotives for the Serb war reparations between 1927 and 1933, 79 were 760 mm gauge locomotives among them.

The first train from Sarajevo passed the watershed of the Sargan Mountain on 25 January 1925. The scheduled railway traffic started soon on the new built Belgrade line connected to the Stalac—Uzice line via Lajkovac-at Cacak station ensuring direct connections between Belgrade and Sarajevo and to the Adriatic Sea ports of Metkovic and Dubrovnik. Having finished the construction of some other lines a large, a more than 2000 km long 760 mm gauge network came into existence in the Serbian-Croatian-Slovenian State by the end of the 1920s, which ran from the Serbian Stalac to the Croatian Knin in the East-West direction, and from Bosna Brod to Plavnica near the Albanian border from North to South. The construction of the new Belgrade Sarajevo narrow-gauge connection established new requirements for the steam traction. The new requirements could be fulfilled only by new locomotive types, but not by the new production of unmodified version of the well proven old locomotives designed and built for the former Bosnia-Hercegovinian lines.

Type 96 steam locomotives
The new Type 96S locomotives, built for the SHS war compensation in 1929, were modified meeting the new requirements. Differently from the same type steam engines delivered between 1911 and 1916, the new locomotives were equipped with MÁV standardised type feed water cleaners system Petz-Rejtő and were put into service without auxiliary oil firing device. The original Type S31 four wheeled tenders were exchanged by new Type S39 eight wheeled tenders. The loading capacity of the new tenders was 5 t coal and 15 m³ water.148

Type 128 steam locomotives
As the track construction works were finished, the 451 km long Beograd—Sarajevo route became the most important connection on the 760 mm gauge Yugoslavian network after the WWI. The journey on this long distance route took very long time because of exchanging locomotives and frequent taking of water. The locomotives, procured by the BHOV to operate on 14-18 %

Fig. 16. Steam engine Type 96 of the MÁV Machine Factory, 1929

The detailed description and power calculation of the type can be found in Annex 9.

Type 128 steam locomotives
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slopes of the Bosna Valley line, were unable to run express and passenger train economically on the high gradient line sections. The heavy Mallet type locomotives put into operation for freight service on the Serbian lines and the 0-8-2 Class IVa5, MÁVAG type locomotives put into service on the Bosnian Mountain lines were authorised to run by 30-35 km/h permitted speed. Putting into service of new Type of locomotives, meeting the new requirements was necessary in order to decrease the journey time between Beograd and Sarajevo. So, thirty-five new powerful, 760 mm gauge superheated locomotives were ordered in Budapest MÁVAG works on the debit of the SHS WWI compensation. The new locomotives were equipped with MÁV standardised type feed water cleaners system Petz-Rejtő.149

The locomotives were put into service in 1930 on the large narrow-gauge network of the Serbian State Railways with No. 1501-1535 of Class IVc6 as a heritage of the BHOV classification. They run in the classification of the Yugoslavian State Railways as Class 85 No 001-035 from 1933. The locomotives were designed according to the new principles invented and applied at the construction of standard gauge steam engines after the WWI. These were the proper utilization of the fuel, the good steam generating capability of the boiler, the good efficiency of the pistons and the optimization of the steam consumption. The results of tests carried out on the MÁV standard gauge locomotives were also utilised.

The 900 HP (662,4 kW) output of the locomotives - according to the factory’s calculation - was similar the MÁV Class 324 main line locomotives. The locomotives could haul trains of 1875 t at 10 km/h and 905 t at 50 km/h speed on flat, 0 ‰ tracks. Their loading capability on 15 ‰ slop at 30 km/h speed was bigger by half of the well proven MÁVAG Type 96 locomotives, running in big number on the Yugoslavian 760 mm gauge network. At the beginning the new type 128 locomotives hauled express train running at their 50 km/h permitted speed on the Beograd—Cacak—Sarajevo line. The journey time was decreased by five hours after putting into service of them.

The further development of the former Bosnian-Herzegovinian 760 mm gauge network gave the possibility to the Budapest MÁVAG works to design and construct the most powerful Hungarian narrow-gauge locomotive type in the 1920s.

The Budapest MÁVAG works kept the manufacture of the well proven locomotives on its production program further. In 1937, a slightly modernised version of the type was offered: equipped with electric lighting instead of acetylene and mechanical pump lubrication instead of hand lubrication. Decreasing of the smallest track curve radius to 80 m was also offered in the Technical Specifications and a further possibility was the application of the exhaust steam

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149 Malatinszky Sándor: A hazánkban szerkesztett és épített legnagyobb teljesítményű keskeny nyomtávolságú gőzmozdonyok (The Most Powerful Narrow-gauge Steam Locomotives designed and built in Hungary – in Hungarian), Budapest, Vasútgépészet, 2003/2, p. 7-12.
The success of the locomotives and the Hungarian industry is characterised by that, the locomotive factory of Slavonian Brod built ten new locomotives Class 85-036-045, in 1940.

The Annex 10 contains the detailed description and power calculation of the type.

### 3.3.2.2 Railway and Industrial Railway Workshops

**Workshops of the Rimamurány Salgótarjáni Ironworks Co., Ózd and Salgótarján**

The substitution of mineral resources lost by the signature of the Trianon Peace Dictate made heavy duty for the industrial railways serving the iron and steel factories remained inside of the new borders. The industrial railway networks of the Diósgyőr MÁVAG works and the Rimamurány Salgótarjáni Ironworks Co. Ózd factory were developed significantly. The rude iron production started again in Ózd in February 1921 after two years of the territory’s Checks occupation of 1919. The Trianon Peace Dictate of 4 June 1920 separated the Ózd factory from the company’s iron ore mines on the Hungarian Highlands in the former Gömör County. The company got the mines of the lonely significant iron field remained inside the new borders in Rudabánya to ensure the continuous raw material supply of the Ózd factory. The 14 km long metre gauge industrial railway serving the mines was converted to standard gauge in 1925. Three of the four steam locomotives ran on the converted 1000 mm gauge line were put into service on the Ózd—Nádasdi Industrial Railway again. One was converted to standard gauge to operate on the Farkaslyuk industrial siding connected to the Ózd rack railway.

The railway workshop of the RMST Ózd built a new standard gauge rack railway and a new adhesion locomotive and further one metre gauge and two 635 mm steam engines in this period. The new locomotives, built in 1927 and 1937 for the 635 mm gauge network serving the steel and the rude mill works, was identical with the 0-4-0 Orenstein and Koppel tender locomotives purchased from the Berlin factory in 1904.\(^{151}\)

The Annex 7 contains the technical data of the narrow-gauge locomotives built by the Workshop of RMST Ózd.

### 3.3.3 The Inventions and Innovations on the Steam Locomotives

The signature of the Trianon Peace Dictate and the fixation of the new borders made also a direct influence on the development of the Hungarian locomotive production. Having lost the MÁV 600-700 km long hill side main lines made unnecessary the further increase of the power and the speed of the steam locomotives. The medium quality coal of the coal fields remained inside of the Trianon borders had to be utilised efficiently in the new type of locomotives. The new requirements influenced changes on the boiler constructions and also on the boiler mountings first of all. The locomotive designers made special care to the construction of the firebox and the arrangement of the smoke tubes taking into consideration the obstacle free flowing up of the steam bubbles, the proper rate of the vaporizer and superheating surfaces in order to ensure the 330-350°C superheating temperature, the proper ratio of the flow sections of the small and large smoke tubes covering the super heater elements, and to ensure the possible largest vapourising water surface and steam volumes of the boiler keeping the weight limitation of the tracks. The cylinders were equipped with large diameter steam inlet and outlet tubes taking into consideration the construction of without sharp changing of directions ensuring the lowest resistance as possible. One part of the locomotives was equipped with exhaust steam injectors instead of piston feed pumps combined with feed water heaters. The exhaust steam

\(^{150}\) Daten zu den Lokomotiven von 0,76 m Spurweite Type 1-D-1 mit überhitztem Dampf zum Betrieb von Schnell- u. Personenzügen, Fabriktype 128. (Data of the superheated 2-8-2, 760 mm gauge locomotives type 128 built for express and passenger service – in German) MÁVAG 1937. Ganz-Archiv

injectors utilised 1/6 part of the energy of the steam streaming out, similar to the feed water heaters. Later steam injectors were generally used on the locomotives instead of water heaters which required frequent cleaning. The different types of feed water cleaners were also tested, and the cascade type of the Prussian State Railways proved the most efficient. The MÁV invented of its application not only on the new but on the modernised locomotives, as well. Sound absorbers were installed on the cylinder waves of the powerful steam engines. **The result of the careful design was the put into service of MÁV standard gauge locomotives Class 424 and 402 operating with the lowest specific coal consumption.** The same principles were applied at the design of the type 128 narrow-gauge locomotives built for the war compensation and the MÁV Class 22 standard gauge steam engines which were the efficient competitors of the GANZ railcars on the secondary lines before the general invention of the Diesel engines. The electric light was used first time on the Class 424 locomotives and also driver’s seats were installed for the staff on the Hungarian locomotives in this period. The steel fire boxes also appeared beside the copper fire boxes on the new built Class 22 locomotives by the influence of the new steel production processes.

### 3.3.4 The Place and the Role of the Hungarian Narrow-gauge Locomotive Production in the Successor States of the Austro-Hungarian Monarchy

The new Trianon borders and the splitting of the Hungarian railway network which was built up consciously from 1868 through five decades brought significant changes in the history of the Hungarian locomotive production. The MÁV Machine Factory had lost the most part of its market but more than the 80 % of the rolling stock production capacity remained inside of the new borders including the Factories manufacturing narrow-gauge railway products except the Weitzer János Machine Factory. The requests and the orders of MÁV forced the Hungarian rolling stock manufacturers to develop their products and production technology. The results of the experiments and tests started in the 1920s - the electrification of the Budapest—Hegyeshalom line, putting into service Kálmán Kandó’s electric locomotives running with induction motors under the 15 kV single phase 50 Hz catenary line, the redesign of the MÁV Class 424 locomotives ordered in the last year of WWI according to the new requirements, the motorization of the secondary lines – defined the activity of the Hungarian rolling stock production for a long time at least five decades and last but not least the international success of the Hungarian wagon works. In this period was designed the most powerful 760 mm gauge Type 128 locomotives of the Budapest MÁVAG works. **The 2/3 of the narrow-gauge steam engines - built in Budapest MÁVAG works in the period between the signature of the Trianon Peace Dictate and the First Vienna Decision - were put into service in foreign countries.**

German and national factories took over the traction unit supply of the successor states’ railway network after 1920, the Skoda Factory in the Czechoslovakian State and the new factories established in Resica and in Bucharest in 1930 in Rumania. The big number of narrow-gauge locomotives built for military proposes during the WWI decreased significantly the demand for the new steam engines. The extension of the Yugoslavian 760 mm gauge network made possible for the Budapest MÁVAG Works to build 79 narrow-gauge steam locomotives for the SHS war compensation. Later the new Yugoslavian Locomotive Factory established in the Slovenian Brod took over production of the MÁVAG Type 96 and 128 narrow-gauge and the standard gauge Type 126 MÁV Class 22 locomotives, as well.

**Hungarian industry could produce great products also in small sizes at the time of between the world wars. The design and construction of Type 128 locomotives in Budapest had the same importance in the history of Hungarian industry in this period as the type “Árpád” fast intercity railcars which were competing with the Budapest—Vienna flights,**

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152 Pető János: Különfelék: A hadikincstár által az erdészetnek átengedhető szállítóeszközök. (*Miscellaneous: Military transport equipment concessible for the forest estates – in Hungarian*) Erdészeti lapok 57. évfolyam 13-14 füzet, 1918. július, p. 258-262
the main line electric locomotives of system Kandó Kálmán running under 16 kV, industrial 50 Hz single phase catenary line on the Budapest—Hegyeshalom line and the Type 122, MÁV 424 class steam engines. The narrow-gauge locomotive production contributed to the success of the Hungarian industry in this period. (*Thesis 9*)

### 3.4 From 1939 to 1944

#### 3.4.1 The Development of the Narrow-gauge Railway Network in Hungary between the First Vienna Decision and 1944

By the first Vienna decision - signed on 2nd of November 1938, in the Golden Hall of the Belvedere Palace - the southern part of the Hungarian Highlands returned to Hungary. By this decision the Hungarian railway network was increased by 1164.5 km, including 121.8 km of narrow-gauge lines. A further 328 km standard and 99 km narrow-gauge line returned after the occupation of the East Carpathian region of Hungary on 15\(^{th}\) of March 1939. A large network of forest and industrial railways was in operation on the returned territories together with the narrow-gauge local lines. As the result of the second Vienna Decision, the length of the Hungarian narrow-gauge network was increased by more than 400 km with the return of the North part of Transylvania railway network was increased by 4789.5 km.

The Hungarian State made strong efforts to improve the traffic circumstances on the returned country lines. Investment on these territories during the WWII was three times greater compared to the previous 19 years. MÁV Headquarters decided to increase the maximum speed up to 60 km/h on MÁV 760 mm gauge lines, introduced the general adoption of the air brake both in passenger and freight traffic, and increased the axle load up to 8-12 t. The MÁV Headquarters ordered new steam engines class 490, diesel railcars, passenger coaches and freight wagons of 15 t load from the Hungarian rolling stock manufacturers for the modernisation of the rolling stock. Putting into service the powerful Type 96 and Type 128 locomotives on the Hungarian 760 mm gauge network was also taken into consideration. Some of the industrial railway locomotives, borrowed by MÁV, were used on the construction works of 760 mm gauge Szászlekence—Kolozsnagyida line, which connected Marosvásárhely to Budapest before the new Dédá—Szeretfalva standard gauge line was finished.

The MÁV took over 43 steam locomotives running on the narrow-gauge lines of the returned territories. Ten of them were put into service by MÁV before 1920 and further four were built also in Budapest Machine Factory.\(^{153}\), \(^{154}\) The Hungarian troops advancing on the Russian frontier took over 16 narrow-gauge steam locomotives and large amount of freight wagon bogies on the liberated territory of the former Galicia in the summer of 1941.\(^{155}\) Some of the locomotives were put into service on the territory of MÁV Kolozsvár Directorate and in the Sub Carpathian regions. The others were delivered to the farm and industrial railways of inside the country. The German Military Headquarters ordered the overhaul of type 96 locomotives - running on the former Yugoslavian network - in the Debrecen MÁV Workshop.\(^{156}\)

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\(^{153}\) Kárpátalján talált MÁV eredetű és nem MÁV eredetű mozdonyok és szerkocsik átszámozása. (Renumbering of locomotives and tenders found on the Sub Carpathian region, which were put into service by and not by the MÁV before – in Hungarian) MÁV Zrt. Központi Irattár GG.10317-529

\(^{154}\) Erdélyben talált nem MÁV eredetű mozdonyok átszámozása (Renumbering of the locomotives found in Transylvania, which were put into service not by the MÁV before – in Hungarian). MÁV Zrt. Központi Irattár GG.10317-529

\(^{155}\) Galiciában talált mozdonyok átszámozása (renumbering of locomotives found in Galicia – in Hungarian). MÁV Zrt. Központi Irattár GG.10326-564

During contracting for the delivery of new rolling stock the MÁV borrowed 21, 760 mm gauge locomotives from the Hungarian private and industrial railways. The MÁV took over three wood fired Type 70 locomotives with number 490,101-103, among them the number GEV 3 steam engine built in 1905 as Type 70\textsuperscript{1} with factory number 1812.\textsuperscript{157}\footnotetext[157]{Bérbé vett mozdonyok átszámozása (Renumbering of the hired locomotives – in Hungarian). MÁV Zrt. Központi Irattár GG.10317-529}

The borrowed locomotives had important role in the construction of the 760 mm gauge Szászlekence—Kolozsnagyida line, which connected the city of Marosvásárhely to Budapest before the opening of the new standard gauge Déda—Széretfalva line considered as the “railway construction of the century". The results of the first and second Vienna Decisions - the returning of some part of the Hungarian territories from the successor states – made new tasks for the technical management of MÁV which was not existed in the previous 20 years on the network of short lines, remained in the Trianon borders.

The narrow-gauge railways and their locomotives got very important role between 1939 and 1944 because of the extension of the networks and increasing of the industrial production.

3.4.2 The Development of the Narrow-gauge Steam Locomotive Production

3.4.2.1 MÁVAG, Budapest

Modernised Type 70 Locomotives

The Budapest MÁVAG works got orders for the production of 30 new narrow-gauge steam locomotives in 1940. Since the construction of Type 127 locomotive, built in 1928, was unsuccessful the 35 year old Type of 70 locomotives was modernised significantly meeting the new requirements of the era. New cylinders were designed equipped with piston valves actuated by Heusinger valve gear instead of the original version. New riveted inner firebox of steel plate was installed on the locomotives changing the original copper one. The boiler was equipped with MÁV-system rapid-type feed water cleaner and sludge collector installed bellow to collect and to draw off the solid components separated from the water. The dome was on the rear section of the boiler barrel. The main steam pipe was led down to the cylinders through the tube plate inside the smoke box. The exhaust pipes were led vertically outside and after entering the smoke joined to the blast pipe. The modernised cylinders were fed by saturated steam.\textsuperscript{158}\footnotetext[158]{The use of superheated steam on the locomotives had a lot of good advantages but had only one disadvantageous. It was necessary to run a four km long distance at least after starting to warm up the cylinders to supply the requested power of the locomotives. The distance between the stations and stops was very short, on the third-class narrow-gauge lines, where the traffic was served by mixed trains in case of steam traction, which was characterised by long stops, including the shunting movements on the stations. The Budapest MÁVAG works made already a design of a superheated narrow-gauge locomotive in the 1920-30s, but in case of the modernisation of the type 70s the super heater was not applied. The experiences gained by the locomotives later proved the use of saturated steam on the locomotives. — Doctorics Benő: Olsóbb-e a Diesel-villamos mozdony útjame a gőzmozdonyokénál (hozászólás Kopasz Károly múlt evi közleményéhez (Is the operation of the diesel electric locomotives cheaper than the operation of the steam engines (Comments on the publication of Károly Kopasz published in the previous year) – in Hungarian. 77/10 (1943) p. 76-77.}

The modernised cylinders were fed by saturated steam.

The next twenty units of Type 70\textsuperscript{15} locomotives were built for the MÁV in 1942 and were put into service with the running numbers of 490,034-053. The locomotives were built for coal...
firing equipped with simple chimney and a basket type spark arrestor inside of the smoke box similar to the standard gauge locomotives. The steam exhausted out from the two-cylinder air compressor was led to the blast pipe through the exhaust pipe on the left side. The driver’s cab could be closed fully by the installation of the double doors on the large openings above the cab doors. Oil lamps, carriage heating valve and tachometer were installed also on the locomotives. The locomotives - authorised to run at a top speed of 35 km/h - were put into service on the Marosvásárhely network but according to the locomotive logs they ran also on the Szatmár—Bikszádi and Szatmár—Erdődi Local Railways and on the lines of the industrial and mine railways, for example on the Gánt mine railway, solving the transportation difficulties of important raw materials delivered for the defense plants.

Fig. 18. The modernised Type 70\textsuperscript{15} locomotive of the MÁVAG Budapest Works, 1942.

Further eight units of Type 70 locomotives were built in 1942. A wood fired Type 70\textsuperscript{16} steam engine for the Ungvár State Forest Estate, three Type 70\textsuperscript{17} coal fired steam engines one for the Gánt Industrial Railway of the Aluminium és Ércbánya Ipari Rt. (Aluminium and Ore Mine Co.) and two for the ephemeral Slovak state\textsuperscript{163}, were among them. Four Type 70\textsuperscript{18} locomotives were ordered by the Hungarian Ministry of Finance. Two and two were put into service on the forest railways of the Visővölgyi and Marosvásárhelyi State Forest estates. By the end of the year the 70 became the Hungarian designed narrow-gauge steam engine type built in the largest number leaving behind the successful, but lighter 75 and 85 Types.

Having put into service the new locomotives, the MÁV ordered further ten Type 70 steam engines in 1942. The new locomotives of the batch of Type 70\textsuperscript{19}, MÁV running number of 490,054-063, were identical with the Type 70\textsuperscript{15} but had already electric lights.

\textsuperscript{160} The double doors saved the locomotive staff not only from the weather, but the locomotives from the attacks of the night fighters as the front lines approached to the Hungarian borders, because the light streaming out from the opened of the firebox doors offered good targets.:

\textsuperscript{161} A mozdonyok műszakrendői próba jegyzőkönyvei (Protocols of the authority test run of the locomotives – in Hungarian), MÁV Zrt. Központi Irattár, Budapest

\textsuperscript{162} A 490 sorozatú mozdonyok mozdonykönyvei (Locomotive Logs of the Class 490 Steam Engines – in Hungarian), Közlekedési Múzeum, Budapest

\textsuperscript{163} The type 70\textsuperscript{17} locomotives were built with copper fire boxes.

\textsuperscript{164} M. Kir. Államvasutak Gépgyára Mozdony és szerkocsi jellegezés (Identification of Locomotives and Tenders - in Hungarian): Ganz-Archiv
3.4.3  The Inventions and Innovations on the Steam Locomotives
The production of new steam locomotives was increased by the enlargement of the railway network and the invented service of military traffic in Hungary from 1942. The MÁVAG Budapest Works built more than 390 new stem engines in the six years passed between the signature of the First Vienna Decision and the November of 1944 comparing to the 600 locomotives produced in the previous 17 years long period. 50% of the new built locomotives was Type 122 MÁV Class 424 steam engines, since the MÁVAG works rejected the production of German war locomotives Class 42 and 52. The Slovakian State Railways put into service four units in 1943 and 1944 with running number 465,001-004. The new locomotives were built with riveted steel inner firebox from 1941. The Type 70 locomotives were also modernised significantly. The most important customers of the 30 modernised Type 70 steam engines were the MÁV and the Ministry of Agriculture. The new born Slovakian state, which bought also two Type 108 – MÁV Class 324 - steam engines putting into service with running number 344,448-457, and two Types of 70 locomotives of running number U46,904 and U45,904 from the MÁV Budapest works, besides the Type 122 locomotives. The MÁVAG Budapest Works got orders also for the design and construction of new locomotives types besides the delivery and modernisation of the old types. Substituting the missing express locomotives, the MÁV Istvántelek Workshop rebuilt a class 203 compound four-cylinder locomotive as a two-cylinder superheated engine on the design of Béla Fialovits. The experiences gained at the reconstruction of steam engine number 301,001 were also utilised at the modernisation of the express engine in the workshop.\textsuperscript{165} The air attacks became regularly after April of 1944. Besides the defence plants also the railway network including the rolling stock were damaged as the targets of the federal aircrafts. To prevent the damages caused by the federal night fighters the locomotives were equipped with covers on the opened side of the driver’s cabs, which shielded the light of the open firebox doors. Similarly, the driver’s cabs of the narrow-gauge locomotives were made closable.

3.4.4  The Influences and the Results of the Vienna Decisions
The most important events of the era were the occupations of the Hungarian territories outside of the Trianon borders, which returned back by the Vienna Decisions and the military occupations. The longest main lines of the MÁV started at Budapest exceeded 600 km again. Narrow-gauge networks were also operated on the returned territories. The firewood supply of the big cities, like Budapest, increased the traffic of the forest railways of the Carpathian Mountains considerably, which could fulfil the transportation demands only by hiring the locomotives from the farm and industrial railways running inside of the country. The establishment of the provisory railway connection of Budapest—Marosvásárhely by the construction of Szászszékence—Kolozsnagýida narrow-gauge line section demanded also new steam locomotives.\textsuperscript{166} The MÁV Headquarters projected to increase the speed of the trains significantly running on the Sub Carpathian and Transylvanian 760 mm gauge networks and the general invention of the air brake both in passenger and freight service, including putting into service of the locomotives designed for the Bosnian-Herzegovinian lines. \textit{Entering into the war of Hungary increased also the traffic on the narrow-gauge industrial and mine railways supplying raw materials to the defence plants}.

The evacuation of the new narrow-gauge railway rolling stock started to safer places when the approach of the invader soviet troops was reported in 1944. Some of the new class 490 and

\textsuperscript{165} The locomotive number 301,001 were damaged at the Biatorbágy bomb outrage when a communist terrorist got the Budapest—Vienna express train to derail on the Biatorbágy bridge on 13. September 1931.

\textsuperscript{166} The extended section of the 760 mm gauge Marosvásárhely—Kolozsnagýida line was constructed by the troops of the Royal Hungarian Army in a few months. The building materials for the construction of the new standard gauge Déda—Szeretfalva line were transported on it. — Dr. Kovács László főszerkesztő: \textit{Magyar Vasútörténet 1915–ől 1944-ig (The History of Hungarian Railways between 1915 and 1944 –in Hungarian)}, Budapest, MÁV Rt. 1997. p. 138.
most of the booty steam locomotives stayed on Hungarian territory furthermore, but the rescue trains entered into the German Empire carried numerous Hungarian narrow-gauge rolling stock. The successor states occupied again the lands which returned to Hungary in 1939-40, according to the Paris Peace Treaty, and the Soviet Union took over and kept the occupied Sub Carpathian region.

3.5 The Second Golden Age of the Narrow-Gauge Steam Locomotive Production (1945-1957)

3.5.1 The Development of the Narrow-gauge Network in Hungary after WWII

As the necessary reparations were carried out the transportation started immediately on the narrow-gauge mine railways and also on the industrial railways of the factories and workshops which were available for the repair and the production of armaments for the invader soviet troops on the occupied territories.\(^{167}\) The agrarian reform took place in spring of 1945.\(^{168}\) The 760 mm gauge network of the AEGV opened for limited public transport was nationalised in December of 1945.\(^{169}\) The reconstruction of the war damages and the restart of the industrial production requested the activity of the narrow-gauge railways.\(^{170}\) The Gazdasági Vasutak Nemzeti Vállalat (Farm Railways National Company) was established in 1947 to solve situation of the land railways which became ownerless after parcelling the agricultural estates.\(^ {171}\) According to the survey made by the company in 1948, 2000 km long mine railways, 2470 km long farm and land railways, 150 km long industrial railways, 700 km long forest railways and 105 km long narrow-gauge railways owned by the War Department were in Hungary after the WWII.\(^{172}\) The MAV took over the operation of the farm railways opened for limited public service after the nationalisation of the narrow-gauge railways in 1949. The Gazdasági Vasutak Nemzeti Vállalat (Farm Railways National Company) was in charge of the reconstruction and operation of former estate railways and set up the Gazdasági Vasút (GV - Farm Railway) network. The Magyar Állami Erdőgazdasági Üzemek (MALLERD - Hungarian State Forest Mills) supervised the forest railways, and the Ministry of industry the mine and industrial railways.

The Ministry of Transport under the direction of Ernő Gerő utilised the popularity of the narrow-gauge railways to reach the Hungarian Communist Party’s political aims for taking over the power in the country occupied by the Red Army.\(^{173}\) The unsolved problem of the farm and estate railways became the instrument of the political propaganda. Having regularized the ownership of the lands a few lines of the former estate railways were lengthened, and the passenger service was introduced. New farm railway lines and networks were built and the scheduled passenger service was introduced also on the lines of forest railways leading to the famous

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\(^{167}\) The Red Army put more than 350 factories under military control in Hungary having occupied the country.

\(^{168}\) 1945 évi VI. Törvénycikk a nagybirtokrendszer megszüntetése és a földmíves nép földhözjuttatása tárgyában (The Act VI. of 1945 on the abolition of the latifundia system and the allocation of the land to the peasant folk)

\(^{169}\) A MÁV Igazgatóság javasolja a közlekedésügyi minisztérenk az Alföldi Első Gazdasági Vasút Rt. megváltását (The MAV Headquarters suggests the nationalization of the Alföldi Első Gazdasági Vasút Rt.) — MÁV Zrt. Központi Irattár 1945 - 52738

\(^{170}\) A gazdasági Főtanács határozata a mezőgazdasági magánvasutak anyagának az állami széntárgyastat részére való biztosítása tárgyában. (The decision of the Main Economic Council on the utilisation of the materials of the private farm railways for the state coal mining) — MOL Közl. M. I/1. 1947-31136


\(^{172}\) Pálmany Béla: Dokumentumok a magyar közlekedés történetéből (1945-1949), Közlekedési Dokumentációs Vállalat, 1981, p. 338:

\(^{173}\) Gerő Ernő (born Singer Ernő; 8 July 1898 – 12 March 1980) was one of the most powerful leaders of the Hungarian Communist Party after World War II and in 1956 until the revolution.
touristic destinations. 300 km was the length of the public railways built in Hungary after 1945, 87 km of which was narrow-gauge.

The annual transportation performance of the busiest Komlói, Oroszlányi and Szobi GVs, which carried coal, stone and sand exploited in very productive collieries, quarries and sand pits, and also the LÁEV reached 5-600 000 tons in the 1950s.174 Double heading of the trains and banking locomotives were frequently used on their lines. Meanwhile the closure of low traffic narrow-gauge lines started at the end of the 1950s.

During the nationalization the narrow-gauge railways the MÁV took over many internal combustion engine locomotives and railcars, which were put into service by the private railway companies before. The diesel electric locomotives of the SzGV, meeting the requirements of the narrow-gauge local railway service, and also the old locomotives of the AEGV, built in Arad and put into service in 1906, were among them. Taking over the rolling stock the MÁV operated them on the lines or networks, where they were put into service originally. Besides the SzGV clear diesel traction was introduced also on the KGV in the beginning of the 1950s. The MÁV started a standardisation program of narrow-gauge railways and most of the 760 mm gauge old locomotives and railcars were modernised and equipped with Ganz-Jendrassik type diesel engines used generally by the Company. In 1956, a new diesel locomotive was built in the Békéscsaba loco shed. Steam locomotives were used in freight and mixed train service on the Nyíregyháza and Sárospatak networks until putting into service of MÁV Class Mk48 diesel locomotives. The dieselization of the narrow-gauge network started early in the 1950s and was also the part of the MÁV 760 mm gauge modernisation program. The aim of the program was the confirmation of third class character of the former fourth-class farm railways opened for limited public service. Along the general introduction of diesel traction, the program contained the increasing of the speed of the trains running in passenger service to 60 km/h, the general use of air brakes also in passenger and freight service, and the modernisation of freight wagon together with the modernisation of passenger coach and freight wagon stock. The base of the program was the principles set up for the modernisation of the North Transylvanian narrow-gauge lines during WWII, with the exception putting into service of diesel locomotives instead of diesel railcars. The general use of diesel locomotives made possible to abandon the steam traction in the freight service. In 1960 the MÁV took over also the supervision of the GV Igazgatóság (Farm Railway Directorate) including the operation of the 1115 km long farm railway network.

Most of the mine, forest and the former estate railways were operated intermittently according to the transportation demands and besides the steam engines only few, low capacity diesel locomotives run on their lines after the WWII, including some 0-4-0 Orenstein & Koppel locomotives. 400 units of diesel locomotives powered by 10-270 LE (7-199 kW) capacity diesel engines were put in service during the reconstruction and modernisation of the narrow-gauge network, in hardly ten years period started from 1952. Most of these locomotives were designed and built in Hungary with the exception of five LOWA- types and some Czechoslovakian built mine railway locomotives. Having finished the dieselisation program steam engines were used in heavy freight traffic furthermore on the Szobi GV, the Balinka and the Pereces colliery and the Özd—Borsodnádasd industrial railway lines in the absence of powerful diesel locomotives.

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174 The Gazdasági Vasutak Igazgatósága (Headquarter of Farm Railways), the operator of the land railways, took over and operated also mining railways. The LÁEV, as a forest railway, transported also large amount of coal exploited from the Diósgyőr colliery and dolomite used for the rude iron production in Diósgyőr and Özd, besides the timber cut in the State Forest Estate of Diósgyőr.
3.5.2 The Development of the Narrow-Gauge Steam Locomotive Production

3.5.2.1 MÁVAG, Budapest

Having signed the Paris Peace Treaties in 1947 Hungary was obliged - among others - to build 800 MÁVAG steam locomotives for the Soviet Union, Czechoslovakia and Yugoslavia besides hand over the locomotives captured as trophy by the Red Army. The Nehézipari Központ (Heavy Industry Centre - NIK) was set up to coordinate the activity of the factories and enterprises involved in the war compensation and took over the control also of the MÁVAG works on 1 December 1946. The extension of the war compensation’s dead line from six to eight years and the new Soviet orders engaged the capacity of the Budapest MÁVAG works, which was ready to fulfil the demands of the Hungarian railway companies only from 1953 and 1956.

The MÁV Machine Factory and the successor MÁVAG Budapest works built 7576175 steam locomotives of 131176 different types from 1872 to 1959, when the steam locomotive production was finished in Hungary. 2095 new steam locomotives were built after the WWII in the Budapest MÁVAG works and nearly 1700 of it were manufactured for the Soviet war compensation and for Soviet orders. 1350 units of class E 177 broad gauge, 234 units of class K 178 750 mm gauge, 54 units of Type 122 (MÁV class 424) and ten Type 70 (MÁV class 490) new locomotives were delivered to the Soviet Union. 55 units of Type 122 (MÁV class 424), 29 units of wood fired Type 70 locomotives, built mainly with copper plate fire boxes, ten Type 94, six Type 96 and one Type 85 new locomotives were put into service in Yugoslavia. Czechoslovakia requested only ten new Type 122 locomotives. Further ten units of Type 70 and three Type 85 locomotives were delivered to Rumania. Three Type 70 locomotives were built for Bulgarian order. The MÁVAG works delivered steam locomotives also over the surrounding countries to Egypt, India and Korea at that time. The MÁV planned to put into service 380 units of Class 303, 415, 424, 516 and 524 first class and 80 units of second class new MÁVAG locomotives after WWII until 1960. However only two, Class 303, 124 units of Class 424, 79 units of Class 375 standard gauge, eight Class 490 and six Class 492 new narrow-gauge steam engines were built in Budapest for the MÁV. The manufacturing of the planned Class 415, 516 and 524 locomotives was cancelled because of closing the steam locomotive production.177

Standardised Type Narrow-gauge Steam Locomotives

The construction of the standardised type locomotives was continued in Budapest MÁVAG works after WWII. Ten locomotives of each Types 85, 94 and 106 were built partly for domestic and foreign orders until 1949. Six new Type 85 steam locomotives were put into service by the MÁV on the former AEGV, BkGV and NyKV networks. The ten units of new Type 106 steam engines were built for the GV Igazgatóság.178 But two third of the standardised type locomotives built at that time in Budapest were Type 70s.

Type 70

The Type 7019 steam locomotives, originally ordered by the MÁV and found under construction in the MÁVAG works, were captured as trophy by the soviet troops occupying Budapest. The gauge of the locomotives was reduced to 750 mm and eight of them were put into service still in 1945 and two in 1946 in the Soviet Union according to the trade agreement made by the

175 The serial number of the last steam engine MÁV 375,1032, built in Budapest and put into service on the 20th March 1959., was 7578, but only 7576 steam locomotives were manufactured in the MÁV Machine Factory Budapest and in the MÁVAG Budapest Works between 1873 and 1959. — M. Kir. Államvasutak Gépgyára Mozdonyszerkezi jellegzés (Identification of Locomotives and Tenders - in Hungarian): Ganz-Archiv

176 The total number of the types was 137 but six were designed only and never built.


178 The „Three Years Plan” of the narrow-gauge railways excluded from public traffic, contained putting into operation of 15 new locomotives in the farm railway service. — MOL Közl. Mú. Eln. 1947-ig. ir.
The class 490 locomotives escaped from the invader Soviet troops from Transylvania and the Sub Carpathian region were put into service on the network of the AEGV nationalised on 1st of December 1945 and also on the mine and industrial railways played important role in the war reconstruction works. The locomotive Nr. 490,034 having converted to 950 mm was put into service and operated for a short time on the Debrecen Városi Gazdasági Vasút (Farm Railway of Debrecen City - DVGV) from the autumn of 1945.

The production of the Type was continued after the delivery of the last 70\textsuperscript{19} locomotive to the Soviet Union. 20 units of Type 70\textsuperscript{20} steam engines were built for the Yugoslavian war compensation in 1947 and 1948. The locomotives were put into service on the 760 mm gauge Yugoslavian network. The locomotives were redesigned according to the demands of the mass production. The steam engines of the last batch, built as Type 70\textsuperscript{21} in 1949 and 1950, were of simpler design, built with steel plate inner firebox. Welding was used instead of riveting where it was possible like in case of the water tanks. The delivery pipes were shortened by installing the delivery valves on the sand box side of the feed water cleaner dom. The locomotives built for coal firing were equipped with MÁV-type conical chimneys and cylindrical spark arrestors in the smoke box. The loading capacity of the coal tanks was increased to 1.3 m\textsuperscript{3} by enlarging its cover plates and the windows on the back side of the driver’s’ cab got circular shape. The 70\textsuperscript{21} was the largest batch of the type including 38 locomotives. The locomotives were ordered for the Yugoslavian railways originally, but ten were put into service in Hungary, eight by the MÁV on the Békéscsaba and Sárospatak networks with numbers 490,054-061 despite they were not equipped with air brakes and MÁV-type safety draw gears. Two were put in operation on the mine railways of the Bükkaljai Szénbányák and the Komlói GV. Most of them were delivered to Yugoslavia except three which were bought by a Bulgarian trade company. These locomotives were built for wood firing equipped with large driver’s cab for the storage of 3 m\textsuperscript{3} woods altering from the other steam engines of the batch. As the last locomotive of the batch 70\textsuperscript{21} left the workshops of the Budapest MÁVAG works in 1950 the production of the Type was finished. 142 units were built in 21 batches between 1905 and 1950.

The demand for the narrow-gauge steam locomotives were changed fundamentally after the WWII. Most of the Type 70 locomotives were put into service on the narrow-gauge local railways and only few were built for the forest and mine railways before, the majority of the 60 units built between 1945 and 1950 were operated on industrial railways. The traffic of the forest and mine railways involved in the war reconstruction and the post war industrialisation increased so significantly that it was not possible to serve economically by the multiplication of low power 30-90 HP (22-66 kW) steam engines. The modernisation of the locomotives in 1942 contributed to the success of the Type.

The MÁV Machine Factory and the MÁVAG Budapest works built 330 units of standardised type narrow-gauge locomotives of 30-90 HP (22-66 kW) power capacity between 1906 and 1950. Taking into consideration the production numbers the most successful steam engines of this power range were the Types of 75, 85 and 106 locomotives. They were used also on the third class local railway networks operated by the MÁV and on the farm railway lines, besides

\textsuperscript{179} The agreement signed by the Provisional National Government of Hungary and the Government of the Soviet Socialist Republics in Moscow on the 6th of April 1945., on the products to be delivered by Hungary to compensate the damages occurred by the hostilities and the occupation of the soviet territories by Hungary. Part II. Railway Equipment, Item 141.

\textsuperscript{180} Later the locomotive was converted back to 760 mm gauge. - Csobai László: A Debreceni Erdei Vasút 80 éve (80 Years of the Debrecen Forest Railway – in Hungarian), Közlekedéstudományi szemle, 12/12 1962, p. 567-563.
the forest and industrial railways. **Including the number the more powerful Type 70 locomotives – as standard type - nearly the half of 969 narrow-gauge locomotives built in Budapest between 1876 and 1950 was of standardised types.**

760 mm Gauge Steam Locomotives of the JZ Type 96

The MÁVAG Budapest works got an order from the NIK for the production of ten, new type 96 locomotives for the account of the Yugoslavian war compensation. The locomotives were built with steel plate inner firebox and the boilers were equipped with MÁV-system rapidis-type feed water cleaner installed on the front section of the boiler barrel. The steam dome and the sand box had common plate casing. Exhaust steam injector and electric lighting were also installed on the locomotives. The driver’s cabs had simple front windows instead of the original oval ones. Eight wheeled Type S39 tenders were built for the Type 96 steam engines. The political relations went wrong in the Eastern block and only six of them were delivered to Yugoslavia. The four locomotives remained in Budapest were converted to metre gauge. The Hardy type vacuum brake was exchanged with Knorr type air brake and the steam engines were put into service on the Pereces colliery and on the Ózd—Borsodnádasd industrial railways in 1950 and 1951.\(^{181}\) Two of the Type 96\(^{5}\) locomotives, remained in Hungary after the WWII, were also converted to metre gauge. One was put into service on the Pereces colliery railway in 1953, and the other was rebuilt in Ózd Workshop for the Ózd—Borsodnádasd industrial railway.\(^{182}\)

**Narrow-gauge Steam Locomotives Built for Foreign Orders**

**Type 135 (Class K\(^{7}\)4)**

Having delivered the last Type 70 locomotives, the Budapest MÁVAG works made an offer for the production of narrow-gauge steam engines to the Soviet Union. Among them was the 750 mm gauge version of the powerful Type 128 locomotives.\(^{183}\) The Type 96 steam locomotives were also known in the Soviet Union besides the Type 70s, since the steam engine JZ number 83-040, captured in Hungary as a trophy locomotive, was put into service on the Harkov Pioneer Railway. Instead of the production of the own types the Soviet Union involved the Budapest MÁVAG works also into the PT-4 project besides the Locomotive Factory Tampele in Finland, the Locomotive Factory Votinsk in Russia, the Czech Skoda works, and the PAF-WAG works in Poland.\(^{184}\) 240 units of the 750 mm gauge locomotives designed by the Kolomna Locomotive Factory, were built in Budapest between 1950 and 1955 as Type 135 and

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\(^{181}\) The loading gauges of the metre gauge Pereces Colliery Railway, built at the end of the 1860s - excluding the loading gauge of the Pereces—Baross Coal Mine tunnel - and the Ózd—Nádasd Industrial Railway opened in 1872., were nearly the same as the invented on the 760 mm gauge lines of the Monarchy in the 1880s. So, putting into service of the rolling stock designed and built originally for the 760 mm gauge networks did not make any difficulties on these lines, but the special equipment had to be installed, like the chain connection under the central buffers on the Pereces lines, and the conventional draw gear - like the standard gauge lines - on the Ózd—Nádasd Industrial Railway. — *Zwillings-Heissdampf Lastzuglokomotive, mit D 1’ Achsanordnung, für 760 mm Spurweite, Fabriktype No. 96-6, mit Schleppendes Achsanordnung 2’2’, Fabriknummmer S 39. (The Twin Machine Superheated Steam Engine of 0-8-2 Wheel Arrangement for 760 mm Gauge Type 96-6 with Eight Wheeled Tender Type S 39 - in German) MÁVAG 1946, Ganz-Archiv,*


\(^{183}\) *Zwillings-Heissdampf-Lokomotive 1-D-1 für 750 mm Spurweite (Sowjet Union) (The Twin Machine Superheated 750 mm Gauge Locomotive of 2-8-2 Wheel Arrangement (Soviet union) - in German) MÁVAG 1951 Ganz-Archiv*

\(^{184}\) The reconstructions, the war reparations, the utilisation of timber cut in the unexplored wide spread woodlands and the reach mineral sources lying far from the urban areas and the busy transportation routes increased the value of the narrow-gauge railways in the war winner Soviet Union. The length of the soviet narrow-gauge network, which hardly exceeded the 13 000 km before the WWII, reached the 100 000 km by the end of the 1960s. Most of the network consisted of 750 mm gauge lines of 4 t axle load, which were portable easy on request. The last version
Russian Class \(K^V4\), referring with letter “V” to their Hungarian origin. Six of the locomotives were put into service in Hungary. The Type 135, Class \(K^V4\) was the narrow-gauge locomotive built in the largest number in Hungary. The total number of the Type PT-4 locomotives exceeded 5100 and it was built in the largest number in the World.\(^{185}\)

The Type PT-4, built with 0-8-0 wheel arrangement, was designed also for coal and wood firing, taking into consideration the Russian geographical conditions. The boiler supplied superheated steam, generated on 37.15 m\(^2\) heating and 13.48 m\(^2\) super heater surfaces. The grate area was 1.01 m\(^2\). The boiler had welded structure but the barrel was joined to the outer firebox with two-rowed riveting. An Everlasting type blowdown valve was installed on the throat plate. The steam of 13 bar, generated in the boiler, was led to the cylinders of the simple engine via a regulator valve system Tzar fitted on inside of the steam dome. The dome had a common plate casing with the sand box. The supply of steam to the cylinders was regulated by Heusinger valve gear. The lubricator pump type FSA, used for the lubrication of cylinders, had an extra cover taking into consideration of the cold Russian winter. The wheel base of the locomotives was 2250 mm and the driving wheels on the third axle were flangeless. The locomotives were equipped with dynamo, electric lighting, pyrometer for controlling the temperature of the superheated steam and steam ejector. The driver’s cab was entirely closed and a was connected with a bellows cover to the six wheeled tender. The tender of welded structure had 5.2 m\(^3\) a water tank and 2 t coal loading capacity. It was equipped with bars making possible the loading of larger volume wood. The locomotive had steam brake and hand brake was installed on the tender. The permitted speed of the locomotives was 35 km/h. Their power reached 160 HP (118 kW), in case of firing good quality coal.

The GV Headquarters put into service four class \(K^V4\) locomotives with numbers 496,075-078, on the Komlói GV line, in 1954. Further two locomotives were put into on the Gánt bauxite mine railway and on the network of the LÁEV.\(^{186}\)

\(^{185}\) The Government of the Soviet Union wanted to ask for the English locomotive factories originally to build the steam engines, which were suffering of the lack of orders after WWII, but because of the cold war it was not possible. The production of the type PT-4 locomotives began in Finland in the Tampele Locomotive Factory in 1946, where 564 steam engines were built put into service in the Soviet Union as class K\(^{F-4}\) until 1952. In 1947 the Votinsk Factory joined to production of the type PT-4 locomotives in the Soviet Union and built 2350 steam engines put into service as class VP-1, VP-2 and VP-4 until 1960. The production of the locomotives started in the Czech Skoda Factory in 1949, where 424 units were built as K\(^{C-4}\) until 1951. The Budapest MÁVAG Works built 240 steam engines from 1950 until 1954 as class K\(^{F-4}\), and further 790 units were built in Poland in different factories until 1957 as class K\(^{F-4}\). The Chinese locomotive factories also took over the production of the type and built nearly 800 units until 1987. — Dr. Csiba József, Malatinszky Sándor, A budapesti MÁVAG gyárbán a szovjet vasutak részére készített K\(^V4\) sor, gőzmozdonyok (Class K\(^V4\) Steam Locomotives Built for the Soviet Railways - in Hungarian), Budapest, Vasútgépészet, 1999/2, p. 3-7., 1999/3, p. 6-8.

\(^{186}\) Having closed the Gánt Bauxite Mines the MÁV GV took over the locomotive class K\(^V4\) of the Gánt Bauxite Mine Railway and put into service as No. GV 496,082. The class K\(^V4\) locomotives of the Komlói GV were also relocated to Szob since the railway was closed. The power of the superheated locomotives could not be utilised economically on the Szobi GV because of the low 10-15 km/h track speed and the short 4 km distance of stations. The star blast pipe – which was generally invented on the MÁV standard gauge superheated locomotives - was also equipped on some of the steam engines of the class but did not show any benefit. The class 496 superheated locomotives were not able to run efficiently on the Szob quarry railway hauling uphill the 6-6.5 t empty stone supplier wagons. The locomotives were withdrawn and scrapped in 1969 ensuring the place for the class 490 locomotives. — Dr. Csiba József, Malatinszky Sándor, A budapesti MÁVAG gyárbán a szovjet vasutak részére
The experiences gained by the locomotives in service did not verify the good results of the loading tests made by the steam engine No K\(^{v}4\)-014 in September 1950 on the Békécsaba—Kaszaper line.\(^{187}\) Frequent derailments, might be occurred by the rigid wheelbase, and week train starting capacity characterised their service on the Hungarian lines. They could run safety only in 40 m radius curves compared to the 0-8-0 MÁVAG type tender locomotives equipped with Klien-Lindner axles negotiating the 30-35 m curve radii. The 3168 kg tractive effort of the engine, calculated from the dimensions of the cylinders and boiler pressure, hardly exceeded the tractive effort of MÁVAG Type 85, MÁV class 492 locomotives. Their tractive effort, originated from the adhesion, was significant lower compared to the tender locomotives prepared and fitted up for starting the trains. The capacity of the boilers could be utilised only at speeds above 20-25 km/h. The official train load of the Class 496 locomotives were nearly the same as of the Class of 490 on the lines operated by the GV Headquarters. The staff of the locomotives had often difficulties at starting the trains because of the unusual super heater applied on the low capacity narrow-gauge steam locomotives. The 16 t adhesion mass of the locomotives was a disadvantage running on the 20-38 \(\%\) slopes of the hill side lines. The loaded tender of the locomotives decreased the effective load of the trains by 12 t.

Type 137

40 units of metre gauge locomotives were built for the order of the Indian Railways as the last Type No 137 of the Budapest MÁVAG works in 1957. The English designed superheated steam engines had 2-6-2 wheel arrangement, and riveted Belpair system boilers. The axles of the locomotive and the tender were equipped with roller bearings.\(^{188}\)

Having delivered the last locomotives built for the order of the Indian Railways in 1957, the production of the narrow-gauge steam locomotives was finished in Budapest. Soon, also the last new built standard gauge steam engine left the Budapest MÁVAG works in 1959, where 7576 steam locomotives were built between 1873 and 1959, and 966 were narrow-gauge among them.

Technical data of the narrow-gauge steam locomotives built by the Budapest MÁV Machine Factory and the MÁVAG Budapest works can be seen in Annex 11.

The narrow-gauge steam locomotives were one of the most important export products of the Hungarian industry related to the number produced after the WWII. 380 units of narrow-gauge steam locomotives were built in Budapest in this period, but only less than ten percent, 32 were put into service in Hungary. (Thesis 10.)

3.5.2.2 Railroad and Industrial Railway Workshops

The low capacity diesel locomotives, put into service in increasing number after WWII, displaced slowly the steam engines on the farm and forest railways. In 1946 and 1949 only two new 600 mm gauge steam locomotives were built by the Workshops of Tatabánya Colliery Company. In 1952 a 600 mm gauge steam accumulator locomotive was manufactured for the industrial network of the Balatonfüzfő Chemical Factory, utilising an old steam engine built by MÁV

\(^{187}\) The traction performance of the locomotives was determined by the caloric value of the fuel, the condition of the track, the slopes and curves, the time table, the weather and the skill of the firemen. The lack of the last could produce even 10-15 \(\%\) difference in the fuel consumptions.

\(^{188}\) Falk Alfréd, Pál József, Villányi György: 100 éves a mozdonygyártás (The 100 Years Old Locomotive Manufacture – in Hungarian). Ganz MÁVAG Közlemények 44. szám, p. 44-
Machine Factory in 1878. Also, a standard gauge new rack locomotive was built and put into service in Ózd in 1953. The duty of the railway workshops was restricted to maintenance and reparation of the steam engine stock and the production of new steam locomotive boilers replacing the old ones operated for more than 50 years.

Meanwhile the number of the steam locomotives operated by MÁV was increased above 1500, maintenance and modernisation of this stock could be carried out by the active contribution of the MÁV railway workshops only. The production of new welded steam locomotive boilers was invented in the Debrecen, Miskolc, Székesfehérvár Workshops and in the former Istvántelek Main Workshop. The solution of the maintenance problems generated by the increasing railway traffic demanded the modernisation of the steam locomotives. The Antidur system for the feed water treatment was introduced generally on the MÁV steam engines, in the 1950s. The period of the planned boiler scale removing could be increased up to six month by this. Smoke box deflector plates were installed on the locomotives Class 424, 301, 328 running in express service. The star blast pipe chimney was installed on all of the steam engines Class 424, 328, 324, 242 and 375, and some part of the of the locomotives Class 442, 411, 342, 327, 301, and 275. The compound engines of the steam engines Class 324 and 375 were converted to simple ones. The electric lighting was generally invented on the steam locomotives and the more efficient type Helm and Erdődy-Osgyáni spark arrestor was installed in the smoke boxes because of the low value domestic fuel.

The boiler, one of the Class 377 locomotives, was exploited during the steam test following the reparations in the Szombathely Workshops in 1948. The replacement of the more than 50 old boiler plates, without examination, were ordered immediately on the MÁV steam engines. The MÁV Railway Workshops refurbished more than 6-800, more than 50 years old, locomotive boilers from 1949 keeping only the cast iron parts. 200 new boilers were produced in the MÁV and industrial railway workshops.

### 3.5.3 The Inventions and Innovations on the Steam Locomotives

The reasons for the invention of the new technical solutions on the steam locomotives after WWII, the general use of welded structure boilers, steel plate inner fire boxes and welded stays, were the simplification of the manufacturing processes and decreasing the costs of the mass production. Having finished the steam engine production in the locomotive factories the railway companies took over the duty of the maintenance, modernisation and development of the large steam engine stock.

The dieselization of the Hungarian narrow-gauge network was forwarding so fast, that the use of the steam locomotives was taken into consideration only for a short time in the future. New type C50 diesel locomotives, built by MÁV Északi Workshop for the forest, farm and mine railways, from 1953 and Class Mk48 diesel locomotives were put into service from 1958. The operation of the steam engines was more and more neglected. Their duty remained only to serve

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189 The fireless steam accumulator locomotives were used on the industrial plants: distilleries, wood-yards, where the risk of the fire was high. Their boiler was filled with hot water and put into under pressure by steam taken from an external source. By decreasing the pressure of the boiler more and more steam was generated in the boiler, so the locomotives could be operated for hours by one charging.

190 Kazánhasználati engedélyek (Boiler licences – in Hungarian). MÁV Zrt. Központi Irattár GG.10307-520

191 Kazánhasználati engedélyek (Boiler licences – in Hungarian). MÁV Zrt. Központi Irattár GG.10313-523

192 Kazánhasználati engedélyek (Boiler licences – in Hungarian). MÁV Zrt. Központi Irattár GG.10307-520

193 The reason of the explosion was the intercrystallite corrosion occurred using the saline feed waters, which decreased the strength of the boiler plates.

194 MÁV eredetű kazánok nyilvántartása (Register of the Boiler Originated from MÁV – in Hungarian), MÁV Nosztalgia Kft.
the transportation peaks besides the low cost diesel locomotives. In 1960 busy steam locomotive service was still on the 760 mm gauge MÁV lines of Békéscsaba, Nyíregyháza and Sárospatak, and on the metre gauge Pérecci Colliery Railway, on the Szob and Oroslány GV lines, on the Balinka and Tapolca mine railways, and also on the metre gauge Ózd—Nádasd Railway. The decreasing number of the narrow-gauge steam locomotives did not require the modernisation of the stock, but the new inventions applied on the standard gauge locomotives, appeared also on the MÁV narrow-gauge steam engines. These were the general use of the Antidur system for the feed water treatment, the electric lighting, the inventions of oil firing on the class 490 locomotives and the star blast pipe system on Class 496 760 mm gauge GV locomotives.195

3.5.4 The Important Events of the Era

Having finished the fighting, the war reparation works started immediately on the occupied territories, including the reconstruction of roads and railway lines and factories able for the maintenance and production of the armaments supporting the military movements of the Soviet troops forwarding to the West. Ernő Gerő occupied the ministerial velvet chair of count Széchenyi István and Baross Gábor with the motto „Who is ruling the traffic that has the power” on behalf of the Hungarian Communist Party on 11th May 1945. The public freight traffic on the MÁV network was started in the summer of 1945, as the Soviet military direction was terminated. The regular passenger service started on the 1st of January 1946. Hungary was a republic for a short time from the 1st of February 1946. Using of royal title on the MÁV official documents was forbidden from 29th of June 1946.196 The reconstruction of the damaged Hungarian railway network was hindered by war reparation obligations, which engaged the full capacity of the Hungarian industry for years. The MÁV Headquarters bought 513 steam locomotives from the stock of the Army of the United States in 1948 to replace the locomotives destroyed, and moved to the Western countries or occupied as trophy by the Soviet troops. Anyhow, this period was characterised by the lack of the locomotives. The invention of the Soviet 500 km and 2000 t on the MÁV and 350 t “Stakhanovite Traction Movements” on the BHÉV (Budapesti Helyiérdekű Vasutak – Budapest Local Railways) network did not show any results but overloaded the locomotive stock.197

New transfer stations were built in the Záhony region to take over the goods to the broad-gauge freight wagons, which were transported to the Soviet Union as war compensation from 1946. The MÁV converted steam locomotives to broad gauge for the shunting movements on its increasing 1524 mm network and put into service soviet Class E locomotives later establishing its own broad gauge tackle stock. The MÁV took over the network and the operation of the former private Szeged Csanádi, Debrecen Nyírbátori and Ajka Csingervölgyi Railways. In 1949 the former farm railways, opened for limited public traffic, like the AEGV earlier, were taken over by the MÁV during the nationalisation utilising their local function. The Gazdasági Vasutak Nemzeti Vállalat (Farm Railways National Company) was set up to organise the reconstruction and operation of the former estate railways and to establish the Gazdasági Vasút (GV - Farm Railway) network, which were estimated more than 1000 km long.198

The use of air brakes in freight service was generally introduced on the MÁV standard gauge network from 1st January 1951. In 1952 the MÁV took over the operation of the BHÉV and the

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196 Közlekedési Közlöny 1946. június 29

197. The aims of the political movements were to increase the load of the freight trains and the daily running performance of the locomotives.

Harasztí—Ráckevei Vasút (Harasztí Ráckevei Railway - HRV) for a short period establishing the network of the Budapesti Elővárosi Vasutak (Budapest Suburban Railways - BEV). The length of the new railway lines built after 1945 exceeded 300 km and 87 km of it was narrow-gauge. The length of the new industrial sidings built after the WWII and operated by MÁV excluding from the public service, exceeded 500 km. The Soviet war compensation duties were replaced by bilateral and long lasting Soviet Hungarian Commercial Treaties from 1953. The fast growing industrial production in Hungary made the MÁV face to heavier and heavier duties year by year from the beginning of the 1950s, which operated the whole public railway network in Hungary excluding the sections of the Győr Sopron Ebenfurti Vasút (Győr Sopron Ebenfurti Railway - GySEV) and the Fertővidéki HÉV (Fertővidéki Local Railway) running in Austria. A new association of the railways, the Organisation for the Collaboration of the Railways (OSShD) was set up in the Eastern bloc based on the model of the UIC in 1957. The basic technical problems elaborated by its subgroups were the long distance mass transportations according to the demands of the members, the Eastern railways.

Large amount of coal exploited in the Donetsk Basin, the iron ore from Krivoy Rog and alumina arrived to Záhony. The transportation of mechanical engineering and agricultural products, live animals, and bauxite containing titan, the rare valuable earth metal, sent to the Soviet Union characterised the freight transportation activity of the MÁV from the beginnings of the 1950s. Because of the busy freight traffic, the MÁV had to develop continuously the Záhony region and the main lines running to that area. Besides the Soviet-Hungarian trade also the domestic coal mines, power stations, factories and construction works increased their inland transportation demands in the 1960s. The industrial development increased the commuter traffic, loading the passenger transportation capacity of the MÁV. The MÁV took over also the operation of the 1115 km long network of the GV (Farm Railway) network, in 1960. The bed condition of the public roads and the lack of public road transportation led to the overload of the MÁV network. The MÁV could met the demands by increasing the axle load of its main line network to 20 t, according to the UIC and OSShD requirements and putting into operation new signaling systems. Besides the increasing freight transportation demands, the MÁV delivered 412 million passengers in 1966 when the number of the employees reached nearly the 170 000. The electrification of the main lines, the dieselization programs, and the modernisation of the steam engine stock, the use of automatic train stopping, and control systems and high sensitivity air brakes were the most important inventions to solve the increasing traffic problems. The MÁV put into service a new class of diesel or electric locomotives year by year from 1950, but in spite of this nearly 90 % of the traction performances was provided by the steam engines on the Hungarian railway network in 1960. The MÁV bought more than 100 units of Class DR 52 and MÁV Class 424 steam locomotives from the Soviet Union, in 1963. The Hungarian industry produced electric locomotives on a licence agreement from 1964 and the MÁV put into service high power diesel locomotives purchased from the Soviet Union. Meanwhile the first practical success of the dieselization was the withdrawal of steam traction on the 760 mm gauge network of the MÁV in 1964. The number of the diesel locomotives running on the narrow-gauge mine, industrial and forest railways was nearly 90 in that year. The closure of the lines performing low traffic density started already at the end of the 1950s, and became a government program in 1968, when the Hungarian Parliament discussed and accepted the “New Concept of Traffic Policy” the concept of stopping the railway traffic on the local and railways where the daily freight traffic did not reach 400 t.

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199 Iparvállalatok Tulajdonában lévő mozdonyok jegyzéke (Register of the Locomotives Operated by the Industrial Companies – in Hungarian). MÁV Zrt. Központi Irattár GG.10317-529
Fig. 19. Refurbished Class K4 steam Locomotive of the Lillafüredi Állami Erdei Vasutak (LÁEV) No. 447,401 at Diósgyőr-Majlát station. (Photo: Ádám Jakóts)
4 The Place and the Role of the Hungarian Narrow-gauge Steam Locomotive Production in the European Steam Engine Manufac-
turing

Hardly eleven years passed after that the scheduled service on the first steam operated railway of the Continent started, when the Pest—Vác railway line was opened for the public. A new iron refinery work and rolling mill, meeting the requirements of the age, manufactured the iron products already in Özd besides the old forge shops of the Hungarian Highlands and the Borsod region from the middle of the 1840s. The young Swiss moulder Master Ganz Ábrahám opened his foundry in the Viziváros (Watertown region) of the city of Buda. John Bailie, the chief engineer of the Magyar Középponti Vasútársaság was a real English man one of the friends of Robert Stephenson. Even so the industrial revolution started only in 1867 in Hungary. The lost twenty years was the age of the experiments in the more developed Western Countries. So it did not mean any disadvantage when Hungary entered in the industrialisation because the latest, most developed technologies could be used at the foundation of the new factories and industrial plants. The reason for the building of the first locomotives in the ÁVT Resica Iron Factory in 1872 was the isolation of the region from the national railway network. The Machine Factory established in Budapest produced in series Austrian designed steam engines for the order of the MÁV and the private railways, from 1873. The first locomotives, designed by the MÁV Machine Factory, the 790 mm gauge Type 3 steam engines were put into service on the Salgotarján Colliery Railway, in 1876. Soon the Type 50, 4-4-2, MÁV Class II. express locomotive of the factory won the Grand Prix of the Parisian World Exhibition in 1900. After the turn of the century the MÁV Machine Factory produced locomotives, which were “European Champions” at time of their first introduction. The Type 105 MÁV Class 601 system Mallet locomotives of the Factory were equipped with the largest boilers in Europe in 1914 when their first units were put into service. Their 2360 HP (1737 kW) effective power output and the 15.51 t tractive effort made them the most powerful locomotives of the Continent. 200 The Type 122 MÁV Class 424 locomotives had the highest boiler centreline in Europe in 1924. 201 The MÁV Machine Factory left also the American locomotive builders by years with the careful design of its system Mallet locomotives. 202 One new locomotive on each day, excluding Sundays and holydays, left the workshops of the MÁV Machine Factory from 1911 to 1916. The number of the locomotives reached 4000 in 1916. The MÁV Machine Fact-
ory built more than 800 steam engines with steel tube Brotan boilers during the years of the WWI setting up a unique record among the locomotive manufacturers of the world. The MÁV Machine Factory could keep the step with the leading European locomotive manufacturers until the end of the WWI. Because of the well-known historical events and the eco-

200 Falk Alfréd, Pál József, Villányi György, 100 éves a mozdonygyártás (The 100 Years Old Locomotive Manu-
facturing – in Hungarian). Ganz MÁVAG Közlémények 44. szám, p. 12.

201 Dr. Kovács László főszerkesztő: Magyar Vasútörténet 1915-től 1944-ig A vontatójárnyévek fejlődése 1915-

202 The operation of the Mallet system locomotives was characterised by the frequent slipping of the wheels driven by the mechanically independent compound system cylinders caused by the wrong steam distribution. The locomotive designers of the MÁV and the MÁV Machine Factory took special care for the best ratio of the volumes of the high and low-pressure cylinders of the compound engines ensuring the good train starting ability of type 46, 62, 87 and 105, MÁV Class 422, 401, 651 and 601 steam engines.
The MÁV Machine Factory and its successor the MÁVAG Budapest works built 7576 steam locomotives ranking its production to the middle section compared to the biggest European locomotive builders’ more than 60 and 75 000 production range. Supposing that the full, 300 units/year, production capacity of the Budapest Factory could have been utilised until 1959, the number of the locomotives built in Budapest had been more than 17000. Taking into consideration a more realistic view the 200 new locomotives per year, the result had reached the 12 500 units. The total number of the steam locomotives put into service in the Carpathian basin was more than 10 000 taking into consideration the production of the foreign factories.

The Weitzer János Machine Factory and Foundry also built steam locomotives for commercial purposes besides the MÁV Machine Factory for a short period. The Arad Factory had its own designed narrow-gauge locomotive types, but most of the locomotives produced in Arad were foreign designs. The machine factories and railway workshops built steam locomotives only for their company’s network.

The MÁV Machine Factory and the MÁVAG Budapest works built 966 narrow-gauge locomotives of 47 types between 1876 and 1957. Their gauges varied between 600 and 1000 mm, but the number of the 750-760 mm gauge steam engines built, approached the 850 among them. Excluding the 240 units of Soviet PT–4 Type, built in Budapest, two third of the locomotives were 760 mm gauge. Their power varied between 30 HP (22 kW) and 900 HP (662.4 kW), their axle loads were between 3 t and 8.5 t. The service weight of the lightest locomotives was 6 t but the heaviest exceeded the 80 t.

Nearly the half of the locomotives, 472 units were standardised type steam engines, designed and constructed according to the demands of the operation and track condition of the domestic and the Carpathian basin’s narrow-gauge railways. Their axle loads were 3.6 t, 4.4 t or 5.5 t according to the track construction standard offered from the turn of the XIX/XX centuries, but accepted only after the WWII. All of the 0-8-0 narrow-gauge locomotives built in Budapest were equipped with Klien-Lindner axles from 1899. Their power capacity varied from 30 HP (22 kW) to 150 HP (110.4 kW). 278 units were built in nine types in this category.

Taking into consideration the production numbers the second largest group of the narrow-gauge locomotives, built in Budapest was made by the steam engines manufactured on foreign designs. The MÁVAG Budapest works often had to put into the shade of the domestic demands accepting the orders for producing foreign designed locomotives. The largest narrow-gauge type 134 of the Factory, was the soviet K¹⁴, 240 units built between 1950 and 1955. The number of the Austrian designed narrow-gauge locomotives built in Budapest was around 80. These steam engines were the invariant versions of the locomotives put into service earlier implementing the tractive stock meeting the increased traffic demands and the locomotives built for the Bosnia-Herzegovinian BHOV network according to the Departmental Order of Baross Gábor the Minister of Commerce. The last type of narrow-gauge locomotives was the 137. 40 units of the English designed metre gauge locomotives were built for the order of the Indian Railways in 1957.

The manufacturing of the 760 mm gauge BHOV locomotives started with the production of the system Klose, Class IIIa5 steam engines in Arad. The MÁV Machine Factory built the heavier version of the class and later manufactured the Type 82 and 96, BHOV Class IVa5, and also the Type 100, BHOV Class IIIb5. The Type 96 locomotives were built in six batches in Budapest, from 1914 and 1948, and thank to the modifications the type became more and more “Hungarian”. The Type 96 was the basis of the design of the Type 128 Class Vlc6 (JZ 85) locomotives.
The miscellaneous steam engines made the fourth group of the narrow-gauge locomotives built in Budapest. Only a few examples or small batches of different types were manufactured. Industrial railway locomotives designed for special requirements, Military Field Railway locomotives and the steam engines of unusual designs like the Type 66 locomotives, equipped with De Dion et Bouton steam engines. The number of the types built between 1876 and 1928 was more than 20, but only a little bit more than 60 locomotives were built compared to the 462 standard type units.

Since, most of the narrow-gauge lines were constructed before the WWI, MÁV Machine Factory and the MÁVAG Budapest works were prepared for the production of steam engines for the 760 gauge railways of the Carpathian Basin and the successor states of the Austro Hungarian Monarchy. Their own designed narrow-gauge steam locomotives had their own characters besides the Austrian designed locomotives.
5 Hungarian Narrow-Gauge Locomotives in the International Comparison

Even before establishing the great national railway companies there were competitions between private railways, which were fighting for the biggest, fastest, the most comfortable, and the most modern title on the fields of the technical development realising it in the buildings, tunnels, bridges and in the symbols of dynamism, the appearance of the locomotives. The MÁV and also the MÁV Machine Factory took part in this competition. Some of its products, including the 760 mm gauge locomotives, could stand the national comparisons in the point of view of the speed, the traction performance, the number of units built and the time of the production.

The history of the Hungarian steam locomotive manufacturing had two outstanding periods, including the narrow-gauge locomotive production. The first lasted from the turn of the XIX/XX centuries until the end of WWI. The second started just before the WWII and lasted to the end of the steam locomotive production. While the busiest 750, 760 and 762 mm gauge lines in the world reached their maximum transportation capacity already in the 1910s, and were converted to broader gauge, as soon as the traffic demands increased above certain economic limits. The Ferrocarril de Antofagasta Bolivia (FCAB) railway put into service its most powerful locomotives on the Companies more than 1500 km long Andes Mountains network, taking into consideration the 12 t axle load and the 762 mm kinematic gauge and soon the network was converted to metre gauge.\footnote{The conversion of the Yugoslavian 760 mm gauge network to standard gauge took place similarly after the WWII. By the end of the 1970s the lines were converted or closed. — Donald Binns: \textit{Kitson Meyer Articulated Locomotives}, Trackside Publications, 2003}

The economic solution for increasing the traffic on the 750, 760 and 762 mm networks was the invention of the larger gauges when the traction power of the locomotives reached the maximum capacity, determined by the axle load and the kinematic gauge. That is why the power of the 750, 760 and 762 mm steam locomotives did not exceed a certain limit compared to the metre gauge ones.

While the first period can be characterised by the giants the second requested economic locomotives built in mass production.

The Annex 12 contains the technical characteristics and comparing tables of the most powerful locomotives built for 750, 760 and 762 mm gauge lines.

\textit{Type 70 Locomotives of the MÁV Machine Factory and the MÁVAG Budapest Works}  
The 70 is the Hungarian designed narrow-gauge steam engine-Type built in the largest number and the largest class of 760 mm gauge MÁV locomotives. 142 units of Type 70 locomotives were built in 21 batches in Budapest between 1905 and 1950. MÁV put into service 61 locomotives on its local narrow-gauge lines between 1906 and 1950 designated as class XXIc. at the beginning, and as class 490 after 1911.\footnote{Kimutatás a mozdonyok és a szerkocsik átszámozásáról, 1911. (The Registry of Renumbering of Locomotives and Tenders, 1911 – in Hungarian) \textit{MÁV Zrt. Központi Irattár GG.10326-564}} According their power and technical characteristics they were the very locomotives of the 760 mm gauge 5.5 t axle load lines built in the Carpathian basin and ran on third class local, and also on forest, industrial and mine railways. Considering the 46 years of production, the locomotives belonged to one of the steam locomotive types built for the longest period.

\textit{Type 96 Locomotives of the MÁV Machine Factory and the MÁVAG Budapest Works}
In the beginning of the 1950s powerful meter gauge steam engines were put into service in Hungary. The locomotives were built in Budapest for the large Yugoslavian 760 mm gauge network, but because of political reasons remained in Hungary and were converted to meter gauge. The locomotives belonged to large family of JŽ (Yugoslavian Railways) class 83 steam engines, of more than 180 locomotives, built in Austrian, German, Hungarian and Yugoslavian locomotive factories between 1903 and 1949.

It was the narrow-gauge locomotive type built in the largest number in Austria, and the most powerful 760 mm gauge locomotive of the Austro-Hungarian Monarchy and the Continent, at the time when they were first built in the Krauss Locomotive factory in Linz. They were also the largest narrow-gauge locomotive Class of JŽ, and the most powerful narrow-gauge steam engines to be put into service in Hungary. These are the most important features of the type, which history has connected to several countries of the region also including Croatia, because of the Dalmatian coast where the lines of the large 760 mm gauge network reached the Adriatic Sea. Another important fact connects this locomotive class to the Hungarian steam engine builders: taking into consideration the compound version of the Class JŽ 83, half of the locomotives were built in Budapest.

Type 128 Locomotives of the MÁVAG Budapest Works
New Mallet system compound locomotives of 2-6-6-2 and 2-6-6-0 wheel arrangements were put into service on the Serbian 760 mm gauge network just before and in the first year of the WWI. Their service weights and the mass of their train loads were heavier, and their grate areas exceeded the features of the MÁVAG Type 128 steam engines of 2-8-2 wheel arrangement designed and built for the Yugoslavian network at the end of the 1920s. Taking into consideration of their 50 km/h permitted speed comparing to the 30 km/h of the Mallet locomotives, the Type 128 superheated simple engines exceeded the locomotives ever built for 760 mm gauge lines. Their effective power competed with the most powerful locomotives built for 750, 760 and 762 mm gauge lines. Their service weight was 83 t taking into consideration of their eight wheeled tender Type S39. Its weight was six tonnes lighter than system Kitson-Meyer steam engine the FCAB 37 known as the heaviest locomotive ever built to 762 mm gauge.

The locomotives of the MÁVAG Type 128 Class JŽ 85 were the most powerful 760 mm steam engines built for express and passenger service and the most powerful narrow-gauge locomotives designed and constructed in Hungary.

Type 135 (Class K⁴4) Locomotives of the MÁVAG Budapest Works
The locomotives designed in foreign factories but built in Budapest made a special group of the steam engines in the History of the A MÁV works. More than 1950 were built during the 82 years of steam locomotive production. More than 25 % of the 7576 steam engines built were not designed in Budapest. The two largest orders for the construction of steam locomotives on foreign design got the MÁVAG works after the WWII. These were the broad gauge Class E⁸ and the 750 mm gauge Class K⁴4 locomotives built for the soviet war compensation and later on a bilateral commercial contract. 240 units of Type 135, Class K⁴4 steam engines were built in Budapest. Most of the locomotives were put into service on the narrow-gauge network of the Soviet Union. They run also on the public, forest, mine and industrial railways. They were used on the new lines built for utilising the forests and mineral sources of the unimproved lands and for the war reparation works and for transporting the raw material on the great industrial projects.

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Malatinszky Sándor: A MÁV állagába besorolt legnagyobb teljesítményű, keskeny nyomtávolságú gőzmozdonyok (The Most Powerful Narrow-gauge Locomotives of the MÁV Tractive Stock - in Hungarian), Budapest, Vasútgépészet, 2001/4, p. 3-9.
Steam locomotives Today and Tomorrow in Hungary

The regular steam service has ended in Hungary in 1984, when Class V42 electric locomotives replaced the Class 424 steam engines running on the last steam operated Vámosgyörk—Gyöngyös line as soon as the construction works of the overhead line ended by the introduction of the new time table. The seasonal steam operated passenger trains running later periodically on the North and South coast lines of the Lake Balaton and in the Danube, band served only for boosting tourism. The number of the MÁV steam engines, ready for service, decreased to 29 by 1991, including also the two narrow-gauge Class 490 locomotives and the Class 220, 302, 335 and 370 engines withdrawn earlier but put into service on the proposal of the MÁV Historical Committee. Nearly 70 withdrawn MÁV standard and four narrow-gauge locomotives were preserved and exhibited as technical relics on railway stations, museums, and different other places. Also some of the industrial railway steam locomotives were preserved.

As the share of the steam traction decreased in the railway transportation performance significantly, the demand increased more and more for the reservation of the old rolling stock as relics for the posterity, or rather to use them further in the tourism or heritage traffic, also on the standard and narrow-gauge lines. **The steam locomotive in operation and reconstructed authentically is the tool for increasing the number of passengers and the incomes, and a special attraction.**

The operation of the steam locomotives running in the tourism and heritage service is characterised by two extremities today. These are: putting into service them with high operational and maintenance costs once or several times a year or rather running them continuously. Another possibility is to operate them in the tourist seasons offering special experience for the guests visiting the regions in determined time periods. Some of the great historical railway companies maintain heritage services on their own budgets but the activity of private persons, the associations and foundations should be taken into consideration, serving efficiently the reconstruction and operation of the steam locomotives, especially in England.

The high operational costs, the difficulties of the operation, the lack of necessary skill for the operation and repairation, the lack of spare parts and procurement of good quality fuel all make heavier the maintenance of the steam traction in the heritage service. The water stations and the coal bunkers of loco sheds disappeared also making problems in the organisation of the routes on the public networks.

Also, the skilled workers competent for the reparations of the steam locomotives are missing. The maintenance staff superannuated. The hard manual labour, the heavy working conditions are not the favourite attractions for the young generations – except some cases – at the age of the computers. This is difficult exponentially at the reparation, maintenance and safety operation of the boilers, which needs experienced engineers beyond the skilled workers. The new

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206 The Austrian Gallup Institute made a market survey for the order of ÖBB in July 1986. 500 passengers of the periodically operated touristic railway, the Schafberg Bahn were asked. 79 % them favoured the steam, and only three the diesel traction. For 18 % of the passengers both could have been acceptable. — Roger M. Waller: *Neue Zahnrad-Dampflokomotiven H2/3 – die attraktive und wirtschaftliche Alternative für Bergbahnen*, ZEV + DET Glasers Annalen 117 (1993) Nr. 4 April

207 The story of the „Barry Scrapyard“ in South Glamorgan, Wales is well known for the English railway enthusiasts. The big yard for breaking up steam engines. was owned by Dai Woodham, who started by breaking up wagons. He was so busy with this work that he never got around to many of the engines. Because of the large amount of freight wagons another kind of vehicles the more than 300 steam engines withdrawn in the 1960s and stored in the yard escaped from scrapping. The steam locomotives attracted to Leicester their lovers from the British Isles, making some restoration works on them at the weekends, and all the locomotives except 20 were put into service by the end of the 1980s.
boilers for the English steam locomotives are made in abroad today. The education of the necessary locomotive staff, the drivers and firemen is also a problem to solve.

Beyond the skilled staff, the maintenance of steam service needs also workshops equipped with special tools and machinery, because of the large dimensions and special technologies applied at manufacturing of the locomotives. The decreasing number of the living steam locomotives gives less and less orders for the special workshops where skilled workers like quality welders should be applied. One of the solution could be to expand the activity of the workshops to other professional fields. One of the good examples is the Meiningen Workshop of DB dealing with reparation of track maintenance machines, cranes and special vehicles beyond the heritage rolling stock.

The other very important condition for maintaining the steam service in the future beyond ensuring the personal condition and the necessary machinery and tools mentioned above, is the reduction of the operational and maintenance costs, by modernising the locomotives or building new ones utilising the possibilities offered by the latest technologies. We can find good examples for both solutions from the last two decades.

**Modernisation and Building of New Steam Locomotives**

Andre Chapelon\(^\text{208}\) in France and Livio Dante Porta\(^\text{209}\) of Argentina reached good results in increasing the thermic efficiency of the steam engines. The principles and methods elaborated by them make the base for the reconstruction of the locomotives taking into consideration the economical operation. The low efficiency of the steam engines could be improved significantly by decreasing the vast of steam flow, the loss of heat in the boilers and cylinders, and the running resistance. The vast of steam flow could be decreased by the proper construction of the main steam and blast pipes, the steam channels of cylinders, and the adequate selection of pipe diameters. The proper heat insulation of the boiler, the cylinders and the main steam pipes led outside improves the efficiency. The use of roller bearings in the rodling and in the axle boxes decrease the running resistance, and furthermore decrease also the operational costs by making the frequent checking, adjusting and manual lubrication of bearings unnecessary.

Most of the steam locomotives are put into service occasionally today. The operational costs are influenced by the long-time of preparation. The occasional warming up and warming down after service characterising the periodic operation increase the maintenance and repair costs of the boilers. During warming up the structure elements of the boiler are lasted by bending moments causing fatiguing stresses by the different expansion of the plates, occurred by the different temperature. The frequent warming up leads to the disruption of the bolts, the leakage of the smoke tubes and to the crack of the plates in extreme cases. The time of warming down can be lengthen by the proper heat insulation, but the real solution is to keep warm the boilers using an outer source for heating and circulating the water, which makes also unnecessary the continuous supervision of the fire and the water level. Further advantage of the solution is that the locomotives can be put into service in a short time in case of extra special requests. The oil or gas firing make easier the service of the locomotives because of the unnecessary fire treatment on the gate area and smoke box cleaning and blasting out of the smoke tubes, which characterise the coal firing. These modifications can be carried out only by losing the original characters of

\(^{208}\) Andre Chapelon (26. 10. 1892. – 22.07. 1978.) was a French mechanical engineer, who gained his fame by the further development of steam locomotives. He was one of the few locomotive designers who applied successfully the scientific methods in their works and put into practice the latest results of the thermodynamic. The results of his research of the wheel-rail contact system were used at the construction of the high-speed TGV lines.

\(^{209}\) Livio Dante Porta (21. 03. 1922. –10. 06. 2003.) was an Argentinian engineer, who reached significant success in increasing of the efficiency of steam locomotives built by him, and in decreasing the pollutant content of the smoke leaving the chimneys.
the locomotives. The SLM Factory in Switzerland built eight new 800 mm and metre gauge oil firing steam locomotives in 1992 and 1996 on the bases of these principles for Swiss and Austrian rack locomotives. The invention of computer technic made possible the one man service of the locomotives regulating the oil firing device. Also, the former SLM Factory modernised the No. 52-8055 locomotive after that.210

The Restoration of the MÁV No. 490,039 Locomotive
The locomotive, owned by the Traffic Museum of Budapest, was transported to Istvántelek Workshop after 30 years of exhibition on Hüvösvölgy station, in December 2004. During the renewal the most important point of view, besides operational requirements, was the restoration of the locomotive to the original state as far as possible to offer and provide real historical values to a railway educating the young generation and last but not least to increase the number of passengers by the new heritage service. The hardest part of the work was the replacement of the 60 years old boiler, which was out of service for the last 30 years. The production of the new boiler was undertaken at the Istvántelek Worksop in Budapest, where a state of the art new boiler was built by the help of MÁV Székesfehérvár Workshop. Some parts of the old boiler were used again, like the fire box foundation ring and the smoke box tube plate, but the riveting was replaced by welding, where it was possible. The fire box was given a bigger fire door hole, and a brick arch. The old water cleaner equipment was removed but its dome was put back without any function, keeping the original form of the locomotive. The boiler was given heat insulation under the boiler casing. The locomotive was given her original chimney with mesh screen placed in the smoke box. The air compressor and the air brake were installed again, including the special direct train brake pipe used on the Budapest hill side line. The main reservoir is in the cab under the coal bunker. State of the art driver’s brake valves were used both for the automatic and direct systems. Also, the cab and the water tanks were renewed. The running gear, the rodding and the cylinders were refurbished.

The tests with the restored locomotive before putting into service on the Children’s railway in Budapest started in May 2007. The official trial run took place also in May. The first introduction for the public was on 9th of June. The MÁV Co. Historical Committee Rolling Stock Section proved the locomotive before its special memorial meeting held on 21st of June 2007, remembering the restoration of the more than 100 years old MÁV locomotive class and the history of Hungarian narrow-gauge steam engine production.

210 Having closed the SLM Factory in 2000, the workshop, dealing with steam locomotives, continued the work as a private enterprise.
Fig. 20. The restored MAV No. 490.039 steam locomotive on Széchenyi-hegy station. (Photo: Sándor Malatinszky)
7 Summary

More than 7760 steam engines, a little bit more than 1050 narrow-gauge among them, were. Eleven steam locomotive builders: machine factories, railway workshops, and workshops characterize the history of Hungarian steam locomotive manufacturing. Narrow-gauge railways played important role in the development of the countries entered into the industrialisation process at the end of 1860’s and at the beginning of 1870’s, like Japan, Hungary and Switzerland. Japan and Switzerland are among the leaders in the modern industrial technology of today. Together with Hungary they achieved the fastest dynamic industrial development before WWI. The 20 000 km long national railway network in Japan is of 1056 mm gauge. Switzerland also had the large gauge network. The length of the Hungarian narrow-gauge lines was 6700 km long in 1918 while the standard gauge network was 18 000 km long. The Bosnian-Herzegovinian 760 mm gauge network was 1700 km long in the Austro-Hungarian Monarchy. After World War II one third of the Hungarian railway network was still narrow-gauge. The operation of narrow-gauge network created special requirements and tasks for the Hungarian steam engine builders.

The industrial culture, the knowledge and the experience, as the background necessary to produce steam locomotives, already existed in Hungary in the years following the Compromise of 1867 and gave intellectual ammunition to the technological development.

The narrow-gauge railways and their steam locomotives were useful means of transportation contributing already in the birth of the Hungarian heavy industry by carrying raw materials and different products on the industrial and mine railways and later the forest and farm railways. They were used also at the construction works of the standard gauge main lines helping the establishment and opening of the new markets for the Hungarian industry and run in the public service on the third-class local railways. They were important export products after the WWII strengthening of the fame of the Hungarian industry in the foreign countries.

The length of the 750, 760 and 762 mm gauge lines reached hardly one percent of the railway network ever built in the World.211 The ratio of the 750-760 mm gauge lines built in the Carpathian basin and in the South-East part of Europe was quite different and it is good represented by the number of the locomotives built. 80 % of the narrow-gauge locomotives and ten percent of the steam engines built in Hungary was 750-760 mm gauge. The construction of the 760 mm gauge third- and fourth-class networks with lower construction and operation costs - compared to the more popular 1000 mm gauge lines in the World - contributed significantly to the success and close up of the countries like Hungary entered into the industrial process late at the beginning of the third part of the XIXth century.

Although the 950-1370 HP indicated power of the 750-762 mm gauge locomotives built in the 1920s competed with the power of the first-class main line locomotives, when the traffic reached the maximum capacity of the lines the narrow loading gauge and the low axle load hindered the further development, so the lines were converted to metre or standard gauge. The 760 mm gauge Budapest—Pestszetlőrinci Local Railway was converted to standard gauge at the turn of the XIX-XX centuries, the Ferrocarril de Antofagasta a Bolivia (FCAB) company converted its more than 1500 km long 762 mm gauge network in the Andes Mountains to metre gauge in the 1920s, and the main lines of the largest Yugoslavian 760 mm gauge network were converted metre gauge after the WWII in the 1970s.

The aim of the dissertation was to highlight the connections between the narrow-gauge steam locomotive production and the development of the Hungarian industry characterised by the

211 Lexikon der Eisenbahn, Transpress VEB Verlag für Eisenbahnwesen, Berlin, 1978, p. 668
good utilisation in synergy the advantages of both virtually independent systems. The connections can be divided into two groups of systems. The first is the large developing 760 mm gauge public network built in the Austro-Hungarian Monarchy until the end of WWII, which was the market of the railway equipment and rolling stock. The second is the role of means for transportation incorporated in the industrial technological processes frequently, including the transportation of raw materials, semi-finished or finished products inside of the factories, industrial areas, and forest or agricultural estates.

The differences between the requirements for the two groups of locomotives are emphasised and the synthesis, the standard types are highlighted, which were good for both services with minor modifications, making possible the production of the most successful types of the factory for many decades. The technical characteristics of the locomotives are examined and investigated by calculations supporting the objective conclusions.

Although it was not aimed originally, but the dissertation succeeded to bring to light the determining role of the 760 gauge lines in the industrial development in Hungary and the reason why so heavy-duty steam locomotives were not built to the 750-762 mm gauge lines like the giants of the metre and 1067 mm gauge networks.

The heritage railway rolling stock, including the narrow-gauge steam locomotives, built in Hungary, represents historical values. Being important relics of our past and part of our national culture, our responsibility is to preserve and demonstrate them for the forthcoming generations, even in working order. The current offers good economic and technical solutions to fulfil it.
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IV.1 Borsod–Miskolci Értesítő, IV. évfolyam, 47. szám, 1870. november 24. és IV. évfolyam, 50. szám, 1870. december 15.; Országos Széchenyi Könyvtár, Budapest.

V Recalls

V.1 Néhai Szontagh Gáspár és Mohay László visszaemlékezései.

VI Photos, Drawings and other Documents

VI.1 A M. Kir. Államvasutak Gépgyára által szállított mozdonyok vázlatrajzai és méretdatai (Sketches and Dimensions of the Steam Locomotives Delivered by the Machine Factory of the Royal State Hungarian Railways – in Hungarian), Klösz György és fia Budapest, 1906.

VI.2 M. Kir. Államvasutak mozdony jellegrajza, Posner és Fia, Budapest, 1899-

VI.3 Plananarchiv SLM, SBB Historic, Winterthur, Svájc.

VI.4 UIC 650 számú döntvény – Mozdonyok és motorkocsik tengelyrendezésének egységes jelölése, 5. kiadás 1983. 01.01, Nemzetközi Vasútegylet.

VI.5 Mohay László: Magyarországi Wöhlert gyártmányú mozdonyok az ipari nyilvántartás alapján, Kézirat.

VI.6 Mohay László: Magyarországi Maschienenbau Gesellschaft (Karlsruhe) gyártmányú mozdonyok az ipari nyilvántartás alapján, Kézirat.

VI.7 Mohay László: Ózdi vasgyár és a Borsodnádasdi Lemezgyár mozdonyai, Kézirat

VI.8 Mohay László: Ózdi és salgótarjáni gyártású mozdonyok az ipari nyilvántartás alapján, Kézirat.

VI.9 MÁV eredetű kazánok nyilvántartása (Register of Boiler Originated from MÁV – in Hungarian), MÁV Nosztalgia Kft.


VI.11 Malatinszky Sándor: Utazz Te is vonattal! Budapest, 1999, MÁV Vezérigazgatóság.