# From a wagon to the steam locomotive - the beginnings of the railroad

History of railways

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The railway is one of the leading inventions which had the strongest effect on the image of the modern world. The steam engine, used as a driving unit, successfully moved a steam locomotive on rails for the first time in 1804.

By 1825 a train had a “developed” form. The emergence of railways marked the beginning of the modern world: the age of mass travel, effective cargo transport at considerable distance, and fast distribution of goods and information on a national and international scale. By 1825 a train had a “developed” form. The emergence of railways marked the beginning of the modern world: the age of mass travel, effective cargo transport at considerable distance, and fast distribution of goods and information on a national and international scale. Sometimes it is difficult to believe that the history of railways begins with carts drawn by horses in ruts …

**In brief**

Stone rutways were already used in the ancient world. The first to come up with such an idea were the Assyrians and Greeks, who for more than six hundred years would use stone ruts to haul ships across the Isthmus of Corinth. On busy roads leading to Rome ruts formed spontaneously, and elsewhere they were man-made. Wooden tracks were put into use at the turn of the Middle Ages and modern times. Continuous attempts were made to improve the invention. The form of transport, used mainly in mines, was brought to the surface by the industrial revolution that started in the United Kingdom. This is where for the first time completely unknown railway became a means of transport available to the public.

A network of railway lines covering the continents made it possible for everyone, who could afford to buy a ticket, to quickly and comfortably reach destinations that had been previously accessible to adept wayfarers only. Trains not only enabled people to travel long distance on land but they also provided a means for quick and smooth freight transport. No carriage was capable of hauling a load of cargo comparable to that conveyed by railway vehicles. The options offered by mass passenger and freight transport accelerated the development of cities, regions and factories. Thus, the history of rail transport is simultaneously the history of progress.

Stone ruts in an ancient road in Pompeii

**Stone rutways**

The railway is not a one-man invention. Many constructors have made their contribution in its development. The ancestral origins of the idea of rail transport date back to ancient times, which is proved by the traces of stone rutways which have survived to date. Craftsmen would carve grooves in stone paved roads in which wheeled vehicles ran. They were particularly useful in the mountains and on winding routes, because they maintained carriages in place, preventing them from tipping to the sides and sliding down steep roads, so they could be safely guided on road bends. The spacing between the wheel-ruts matched the ordinary wheelspan used in the specific area and – depending on the region – it ranged from approx. 1,350 mm to 1,500 mm. Probably the normal gauge of 1,435 mm, now the most common railway gauge over the world, derives from rut spacing popular as early as 1630.

**Might is right on the passing loop**

The definite majority of roads were single lane, so passing loops were designed at certain intervals to enable vehicles travelling in the opposite direction to pass through. If the vehicles met between the passing loops, the less stately or simply the weaker traveller had to retreat with his carriage to the nearest passing loop or temporarily pull over to the side of the road. Often, the passing right was a reason for disputes or even duels since not everyone was willing to give way. In the Greek myth about Oedipus, the hero – refusing to give way – killed an old stranger (who in fact was his father, Laius) approaching from the opposite direction. The above-mentioned episode indirectly proves that rutways did exist in ancient Greece. With time road surface was lined across with stone slabs and

wheel-ruts gradually disappeared. The travelling method used in the past was revived only after many centuries.

**The rattle of wheels on wooden tracks**

Tracks – in the form known to us – assuredly derive from wooden planks preventing wheels of load carrying barrows or carts from getting stuck in sandy or muddy ground. Such provisional “tracks” made of planks are also built in our times, e.g. in construction sites. Assumedly, already our medieval ancestors erecting monumental castles and cathedrals built them.

But the real track was not built in the construction site but it came to life underground. The first primitive trackways were built in coal and iron ore mines for the needs of horse-drawn tubs and human-powered carts. At that time natural wheel-ruts reinforced with timber were used as rails. However, the most frequently used solution involved chutes built from planks in which the additional fifth wheel at the front of the vehicle would run. Later, the planks were replaced by wooden beams. The beam rails were nailed to wooden cross-ties. Such trackway was used to transport hard coal and ores from the drift in small trolleys. This was a significant convenience for miners who previously had to carry all the coal from the mine to the surface on their backs. In the narrow headings rails not only eliminated the problem of mining trolley wheels sinking but also outline their track for safety reasons. In the darkness under the ground it was possible to overrun people or other trolleys. The first tracks outside the mine were built in England around 1600.

Wooden tracks preserved in the medieval silver mine in Suggental, Germany

Trolleys filled with coal or ore were pulled by horses to the local river or canal or to the seaside where the cargo was loaded onto vessels. One draft horse was capable of transporting the amount of

coal corresponding to the amount carried by as many as 30 pack horses. With time wooden tracks were also put into use to transport other materials, e.g. products from factories or stone blocks from quarries. Many trolleys were equipped with wheels with a special bulge on the inside thanks to which they did not slip off the rails and stayed on the right track all the time. This invention can be observed in contemporary trains.

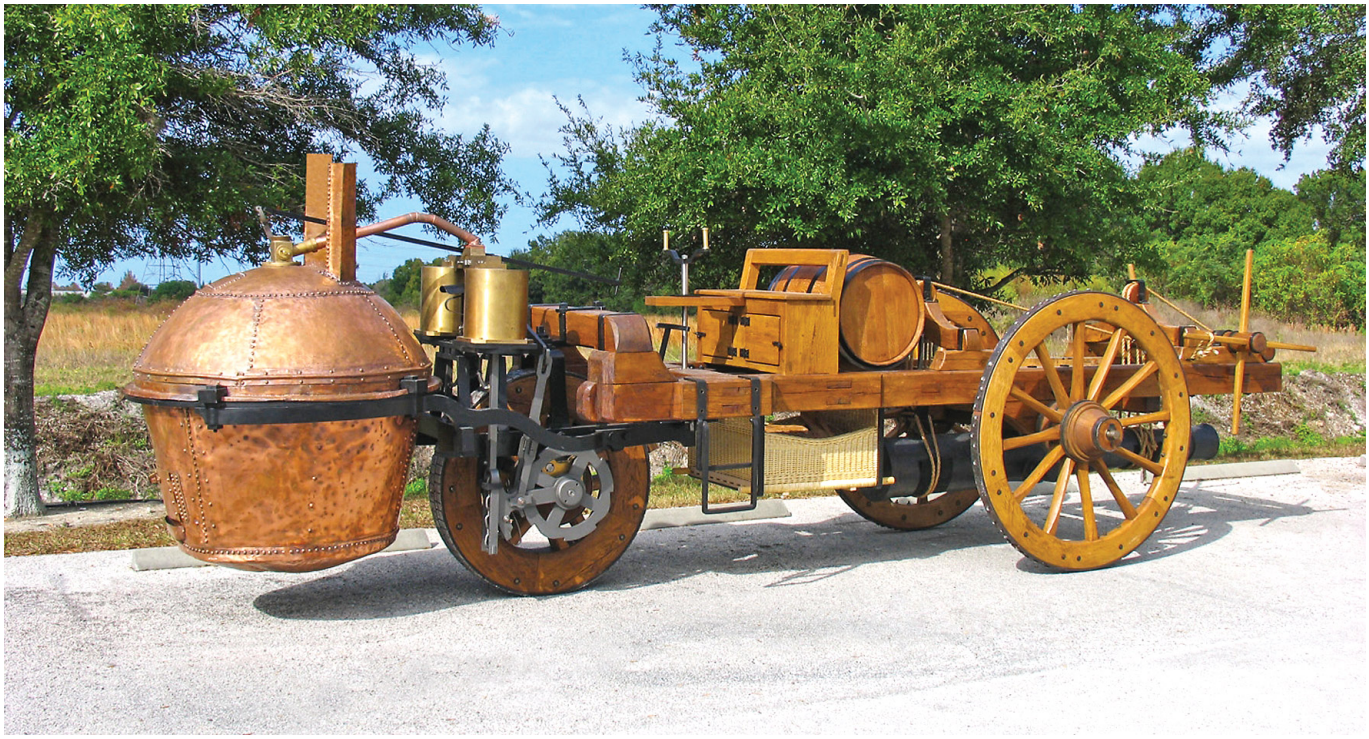
The material from which the rails were produced at that time, that is timber, had two serious drawbacks: firstly, it was quickly worn out and secondly, wooden tracks could not carry excessive loads. Soon, an improvement was introduced – it consisted in reinforcing the tracks with metal strips; later they were covered with iron or cast-iron plates. To the order of Richard Reynolds, the owner of ironworks, in 1767 long narrow plates were cast from iron and nailed to rails. Such reinforced tracks could be used to carry much heavier loads and the carriages rolled much more smoothly. Reynolds' decision was influenced by economic crisis and the related rapid drop in prices of metallurgical products.

At that time the director of large metal works in Coalbrookdale decided to stop the sale of cast iron produced there until the prices rose again. To prevent the overstuffing of warehouses, he ordered the temporary use of cast iron plates to reinforce tracks owned by a wooden transport track company. Cast iron reinforcement proved to be stronger than timber and it quickly gained popularity.

**Then there came cast iron**

The structure of the rail track materially changed in the second half of the 18th century with the invention of an L-shaped cast iron rail. In 1789, an Englishman, William Jessop, used a rail resembling the shape of a contemporary rail. He put carriages equipped with flanged wheels on tracks made completely from cast iron. Soon, his invention was brought to the largest European economic centre at that time in Upper Silesia. Thus, horse-drawn narrow-gauge industrial railway was put into operation as the first railway in the present-day territory of Poland and at the same time on the European continent.

Cast iron tracks increased transport capacity 10 to 15 times. Thus, at the turn of the 18th century numerous societies were formed to take up the construction of new horse-drawn railways for the needs of industry and trade. Iron rails were in use from 1820 and steel ones – from 1862.



The steam-driven vehicle invented in 1769 by Nicolas Joseph Cugnot

**The difficult birth of the steam locomotive**

A stationary steam engine is believed to have been invented by James Watt, who in 1763 improved the atmospheric steam engine built previously by Thomas Newcomen. This was the general starting point. The birth of the steam locomotive was difficult and entailed many dramatic events.

As steam engines became better and better some visionaries began thinking about the possibilities of using them as vehicle drive. The direct predecessor of the steam locomotive was the structure built by Nicolas-Joseph Cugnot in 1769. The French officer was awarded a contract to deliver an artillery tractor by the French Ministry of War. Inspired by the steam engine which at that time was used in mines and factories, continuously developed by James Watt, he wished to build a steam-powered vehicle similar to the structure described as early as in 1663 by the English physician, astronomer and mathematician, Isaac Newton. In 1769 the ordering authorities were presented with a vehicle with three wheels and a huge boiler. Water, heated up in the boiler, made the machine move for about 10 minutes. After this time, water had to be heated again to move it further. Encouraged by this achievement, Cugnot added fire under the boiler which extended the vehicle's travel enabling it to move with a stunning speed of 2.5 mph (4 km/h). However, it was poorly steerable, which resulted in an incident. During the show organised for high rank military personnel the invention went out of control and made for the observers, causing general panic and terror, and finally hit a wall. After this accident works were not continued any more as Cugnot's vehicle was regarded too dangerous. The concept of steam-powered vehicles was not undertaken for a longer period of time.

Nicolas Joseph Cugnot trying to stop his self-designed steam engine vehicle after an accident during presentation in 1771

**… and other prototype failures**

James Watt and engineer William Murdoch also examined the possibility of using a low-pressure steam engine as a vehicle drive. Murdoch, who in 1786 in the village of Redruth in England tested his invention equipped with a boiler heated by a spirit lamp, also had to face difficulties. He heated the boiler in the carriage standing in the middle of the street but did not have time to get on. The steam carriage running without a driver scared the local pastor who suffered such a shock that he died shortly afterwards.

Soon, Murdoch employed a talented worker, Richard Trevithick, who claimed that low pressure in the boiler was not sufficient to drive a vehicle and that it should be sealed well to increase the pressure up to approximately 3 atm. Trevithick's trial on Christmas Eve of 1801 was not successful. The steam carriage, in which he travelled together with his friends, tripped over and fell into a ditch. Nobody was hurt. The machine was also damaged but the distressed participants changed their plans and spent the rest of the evening in an inn over a boozy dinner. The steam carriage, left in a shed, burnt down. In 1803 in London, Trevithick built another machine. It moved efficiently in the streets at 7.5 mph (12 km/h). Because it scared away horses and frightened passengers, it was boycotted by Londoners and the press.

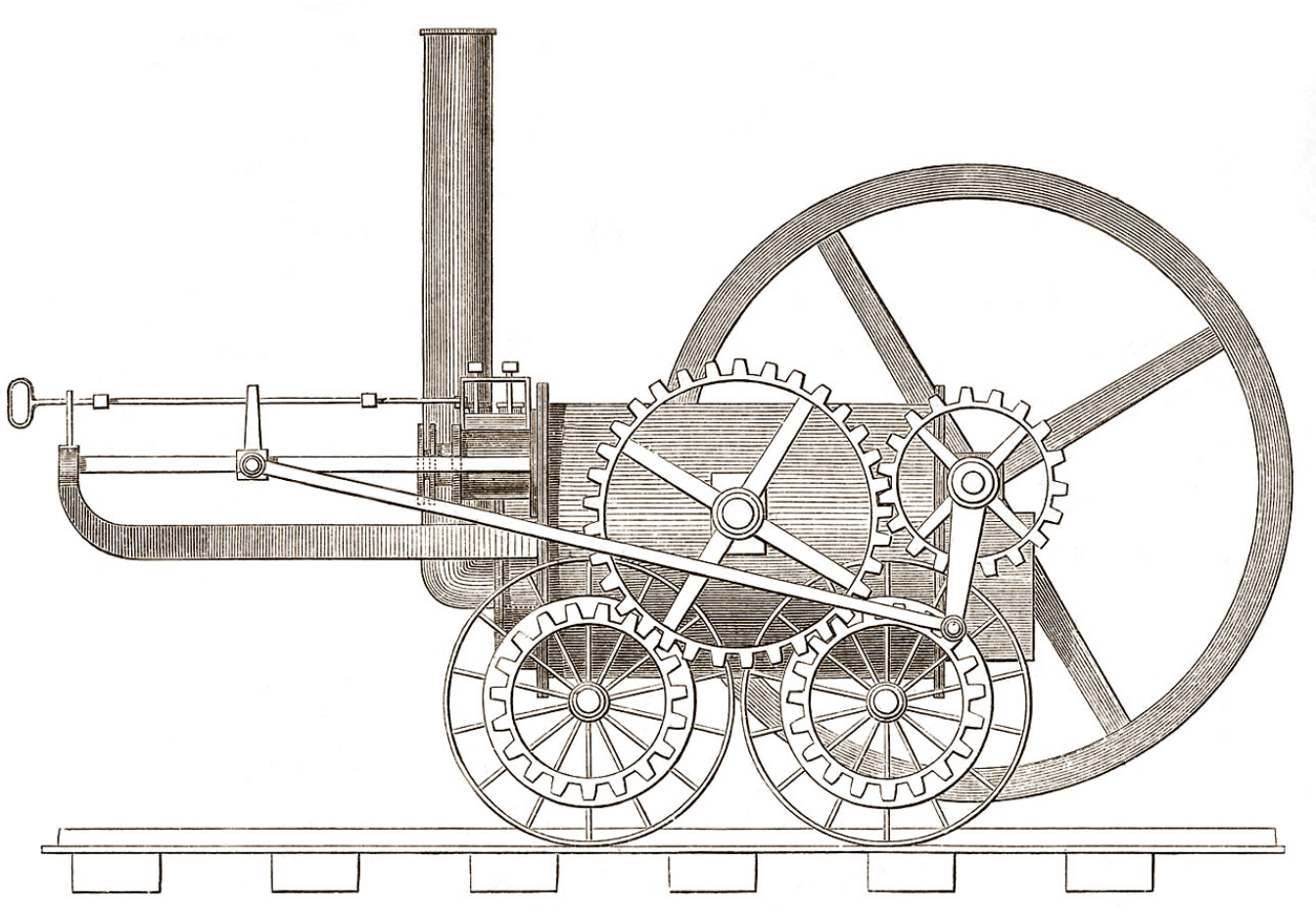
**The "marriage" of a locomotive and a rail**

While working at the Penydarren Ironworks in South Wales, Trevithick persuaded their owner, Samuel Homfray, to build a steam engine to replace horses pulling carriages loaded with cargo to

Abercynon, 9 miles (15 km) away. During the inaugural drive on 22 February 1804, 5 carriages carried 10 tons of iron and 70 passengers. The set was pulled by the first operable steam locomotive with a flywheel. The pressure in the boiler reached 4 atm. It took 4 hours and 5 minutes to travel a route longer than 9 miles (15 km). Trevithick's steam locomotive made multiple runs on this route, pulling loads up to 25 tons. Under the load of a 5-ton steam locomotive and its cargo the light rail track was quickly worn out. In turn, when the weight was reduced the vehicle lost its grip and could not be driven. Having found that the maintenance of a line was very costly, Homfray withdrew the steam locomotive and restored horse-drawn vehicles to operation.

**The wheel of business**

Attempts to build steam locomotives and put them into use did not result from the accomplishment of the fantastic ideas of the 18th and 19th century designers. It was the development of industry and trade which increased the requirement of new means of transport. As early as the 18th century more and more bridges were constructed, while roads were hardened and widened. The improved transport network gradually made industrial plants independent of water routes. The development of factories was conducive to the emergence of large transport companies. At that time, one such company in London had 3 thousand horse-drawn carriages and 30 thousand employees. In France transport companies carried more than 700 thousand people in 1840.



A scheme presenting the steam locomotive built by Richard Trevithick - 1803

**THE WHEEL AND RAIL CHALLENGE**

New inventions often meet various adversities on their way to excellence. A challenge for steam locomotives was … matching wheels and rails. The problem for the first steam locomotives was their insufficient adhesion weight, bad condition of rails and the superstructure, and people not

understanding this thought that natural friction was not enough and it should be increased by artificial methods. The idea of reducing the weight of the locomotive was developed by adding an extra, corrugated rail to drive the machine. The man behind this idea in 1811 was John Blenkinsop. Another, even braver, concept assumed the installation of special mechanical legs, imitating a walking animal, to put the locomotive into proper motion. Such a vehicle was constructed in 1813 by William Brunton.

**The first functional steam locomotive**

However, none of those solutions was successful. Thus, the previously abandoned concept of making use of the natural grip between the wheel and the rail was resumed. Above all, this was a contribution by William Hedley, whose experiments demonstrated that the condition for the movement of vehicles on smooth rails is sufficiently strong pressure on the driving wheels. And so, in 1813 the first functional adhesion steam locomotive of his design, called “Puffing Billy”, was built and it remained in use until 1862.

**Stephenson – a coal mine engineer-wright**

Regardless of Hedley, George Stephenson – an engine-wright for the collieries at Killingworth – took interest in steam locomotives. He managed to persuade the management board of the company to commence trials with a locomotive of his own design. Having obtained permission, in 1814 he built a two-axle adhesion steam locomotive with a wheel diameter of 914 mm. He used a steam engine identical to that used in Hedley’s locomotive. But due to poor thermal characteristics (insufficient heating surface, a single fire tube, insufficient funnel draught – and an excessive diameter of the funnel: 510 mm) satisfactory results were not achieved.

But Stephenson was not discouraged. Spurred on by Hedley’s results, in 1815 he built a new steam locomotive in which the wheels were joined initially by means of rigid connectors and later by means of a chain in order to increase the adhesion tractive force. In his next locomotive, built in 1816, Stephenson introduced springs in the locomotive to avoid the use of a gear drive. This lifted off the hazardous impact of uneven tracks and enabled even distribution of wheel load.

**New is not always better**

Nearly every year until 1829 new types of steam locomotives were built which did not differ from the previous models in terms of values. Attempts to improve the thermal characteristics of the locomotive boiler proved pointless as it was impossible to ensure the appropriate heatable surface by means of a single fire tube. Moreover, as a result of imperfection of the mechanical parts, maintaining a steam locomotive in motion required continuing costly repairs. Also, the condition of rails had a disastrous effect on railway operation. The rails were made of short, cast bars of iron. The tracks, not suitable for heavy vehicles, kept on cracking, thus increasing traffic maintenance costs. In addition, the disproportionately high number of contact points increased rolling friction and, due to dynamic stress, impaired vehicles’ chassis that were imperfect anyway.

**However, despite multiple obstacles and critical opinions the interest in railways was growing**

But despite great obstacles and lack of interest, interest in the railway industry was still growing. 1820 was a turning point that brought a ground-breaking invention to humanity. At that time, John Birkinshaw, an engineer at the ironworks in Durham, put rolling wrought-iron rails into use. They were much longer than the previously used cast-iron rails. Stephenson found them useful in 1822 during the construction of the first large railway line between Stockton and Darlington, designed

mainly for the needs of transporting coal from the local coal basin to the harbours in the north of England.

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