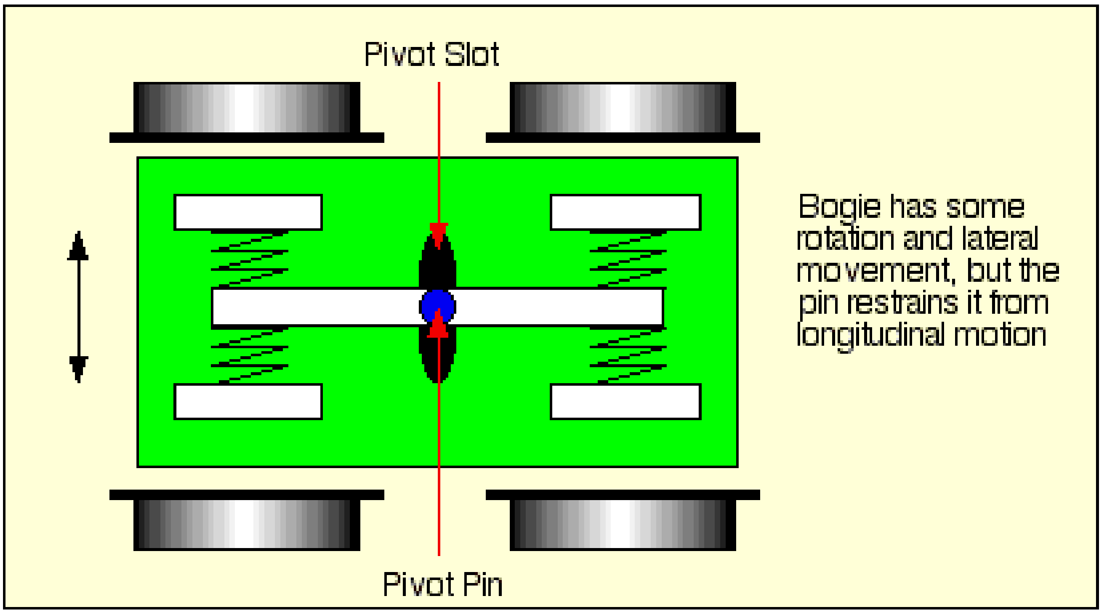
Bogies, Trucks, Radial Axles and Others.

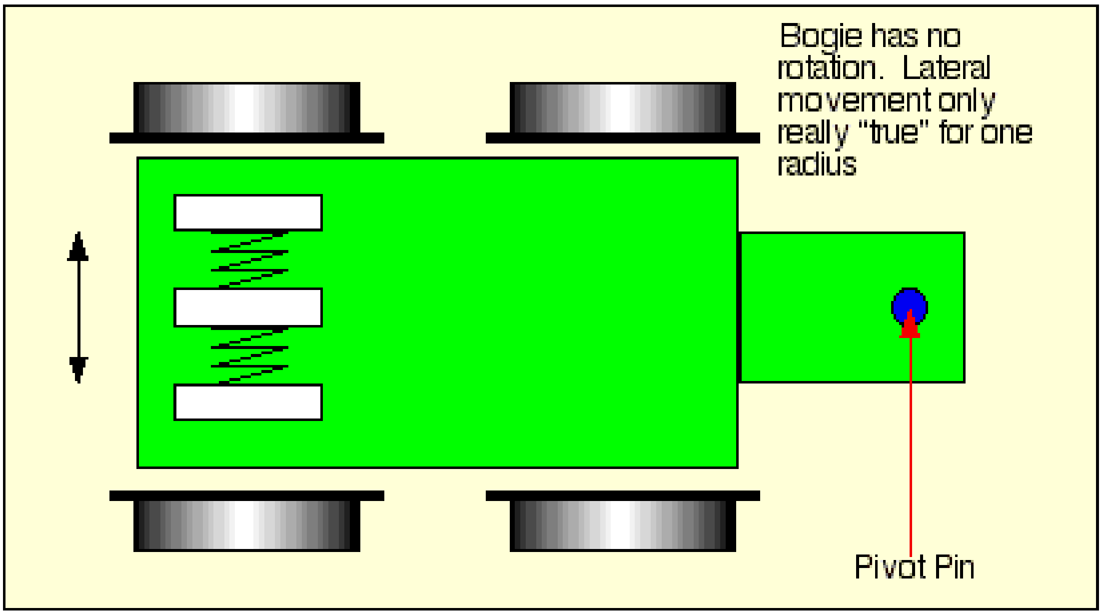
The Adams Bogie.

William Adams (1823–1904) was the Locomotive Superintendent of the North London Railway from 1858 to 1873; the Great Eastern Railway from 1873 until 1878 and the London and South Western Railway from then until his retirement in 1895. He is best known for his locomotives featuring the Adams Bogie, a device with lateral centring springs, (initially made of rubber), to improve high-speed stability.



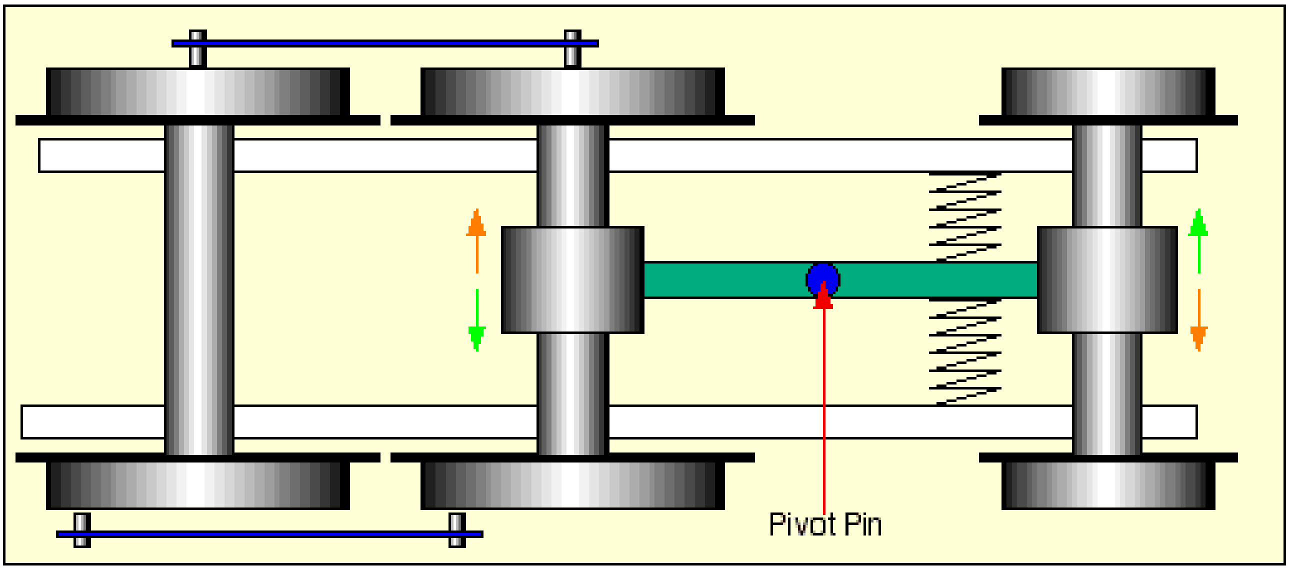
The Bissel Bogie.

The Bissel bogie, (Bisselgestell), is a very simple and commonly used way of designing a carrying axle on a locomotive to enable it to negotiate curves more easily. Its invention is generally credited to Levi Bissel, who devised one in 1857 and patented it the following year. A Bissel bogie is independently installed in the frame, and sideways guidance of the locomotive is achieved by elastic forces. The distribution of these forces is not tightly defined and, in addition, they are dependent on the curve radius.



The Krauss-Helmholz Bogie.

The Krauss-Helmholtz bogie, (Krauss-Helmholtz-Lenkgestell), is a mechanism used on a locomotive, where a carrying axle is connected to a coupled axle via a lever such that when the carrying axle swings to the side on going round a curve, it causes the coupled axle to move sideways in the opposite direction. In this way the radial forces during curve running are more or less evened out on both axles, so that riding qualities similar to those of a normal bogie are achieved and wear and tear reduced on wheel flanges and rails. The bogie was named after the locomotive firm of Krauss and the engineer, Richard von Helmholtz. Because the advantages of the bogie come into play particularly on tight curves, the Krauss-Helmholtz bogie initially appeared on branch line and narrow gauge locomotives. One of the first locomotives of this type was the Bavarian “D VIII” Class. On this tank locomotive the bogie was located at the rear; however in the majority of cases it was at the front, or, if the locomotive had to have equally good riding qualities in both directions - at both ends. Later this pony truck arrangement was also adopted by the DRG standard gauge locomotives (Einheitslokomotive) of the Deutsche Reichsbahn, e.g. on the ten-coupled classes: 44 (2-10-0), 45 (2-10-2), 50 (2-10-0) and 85 (2-10-2).

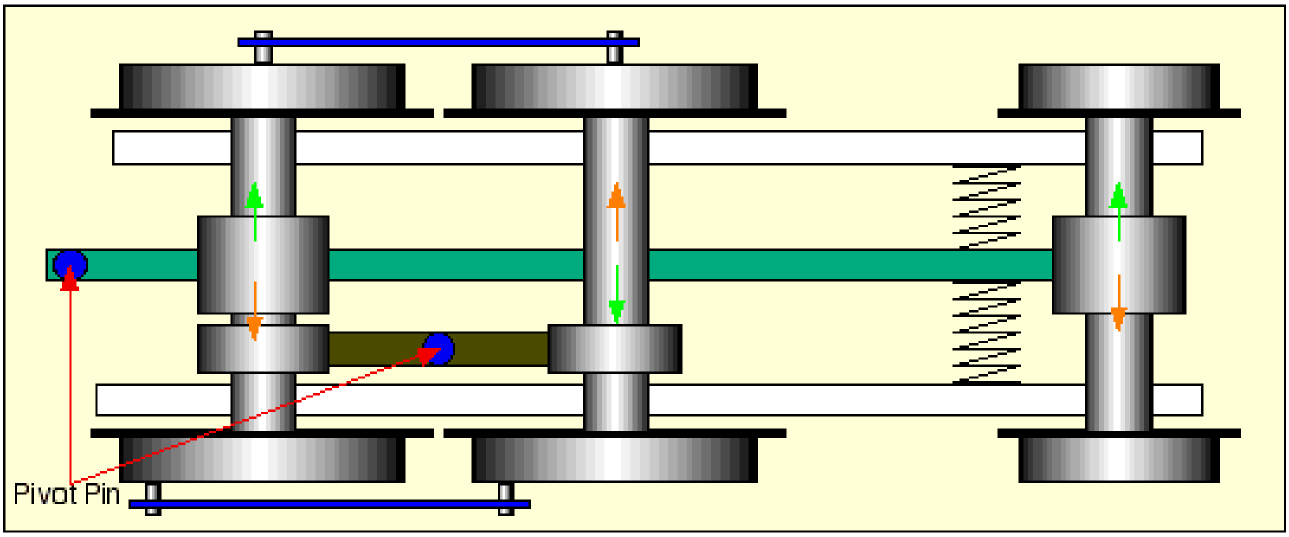


The Jacobs Bogie.

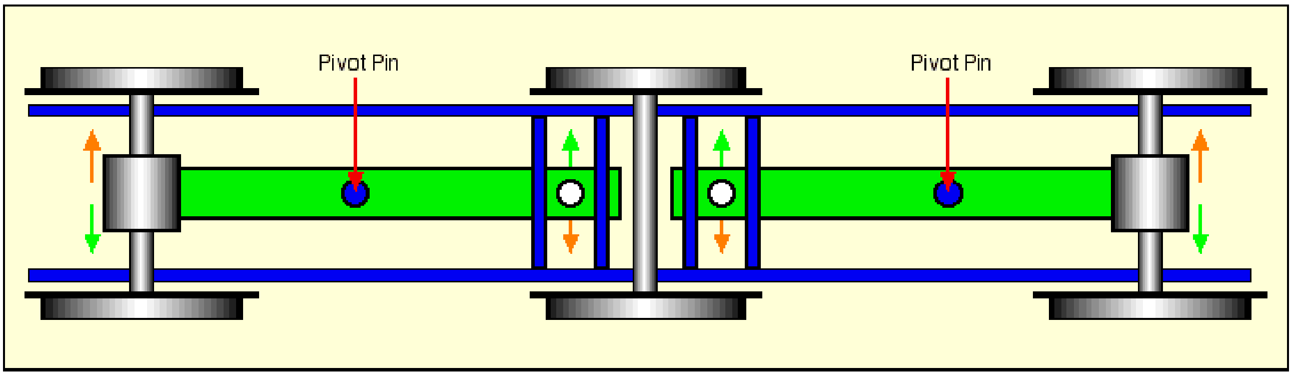
Jacobs bogies (named after Wilhelm Jakobs [1858–1942]) are a type of rail vehicle bogie commonly found on articulated railcars and tramway vehicles. Instead of being underneath a piece of rolling stock, Jacobs bogies are placed between two carbody sections. The cars on either side spread their weight on one half of the Jacobs bogie each. Vehicles featuring Jacobs bogies are, as an example, the TGV and Eurostar trains, the Talent series of multiple units, the LINT41 and the Class 423 S-Bahn vehicles. A disadvantage of vehicles using Jacobs bogies is they are semi-permanently coupled and may only be separated in the workshop. In the United States, such configurations have been used throughout the twentieth century with some success on early streamlined passenger trainsets, such as the Chicago, Burlington and Quincy Railroad's Pioneer Zephyr and Union Pacific Railroad's M-10000. Intermodal freight trains, such as Pacer Stacktrains, use container flatcars in groups of three to five cars, connected as a unit with Jacobs bogies. In Australia, Jacobs bogies were first used on the B class Melbourne tram in 1987 on two tram-converted former suburban railways. Some triple-bogied two-section electric locomotives such as the NZGR EW class have an articulated body supported on the centre bogie. Other types of Bo-Bo-Bo locomotives instead have a body shell, with enough allowance for sideplay in the central bogie.

Schwartzkopff-Eckhardt Bogie.

The Schwartzkopff-Eckhardt bogie (Schwartzkopff-Eckhardt-Gestell), is a further refinement of the Krauss-Helmholtz bogie, whereby two coupled axles and the carrying axle are combined within the bogie. The carrying axle steers the second coupled axle via a long shaft and this also moves the first coupled axle via a lever. This bogie is used on the DRG Class 84, (2-10-2). It was named after the L. Schwartzkopff locomotive factory and its chief engineer, Friedrich Wilhelm Eckhardt.



The Clemenson Truck.



The Clemenson Truck uses two axles pivoted half way with the remaining length of the lever captive on the centre section. The action of cornering forces the central axle to conform to the curve.

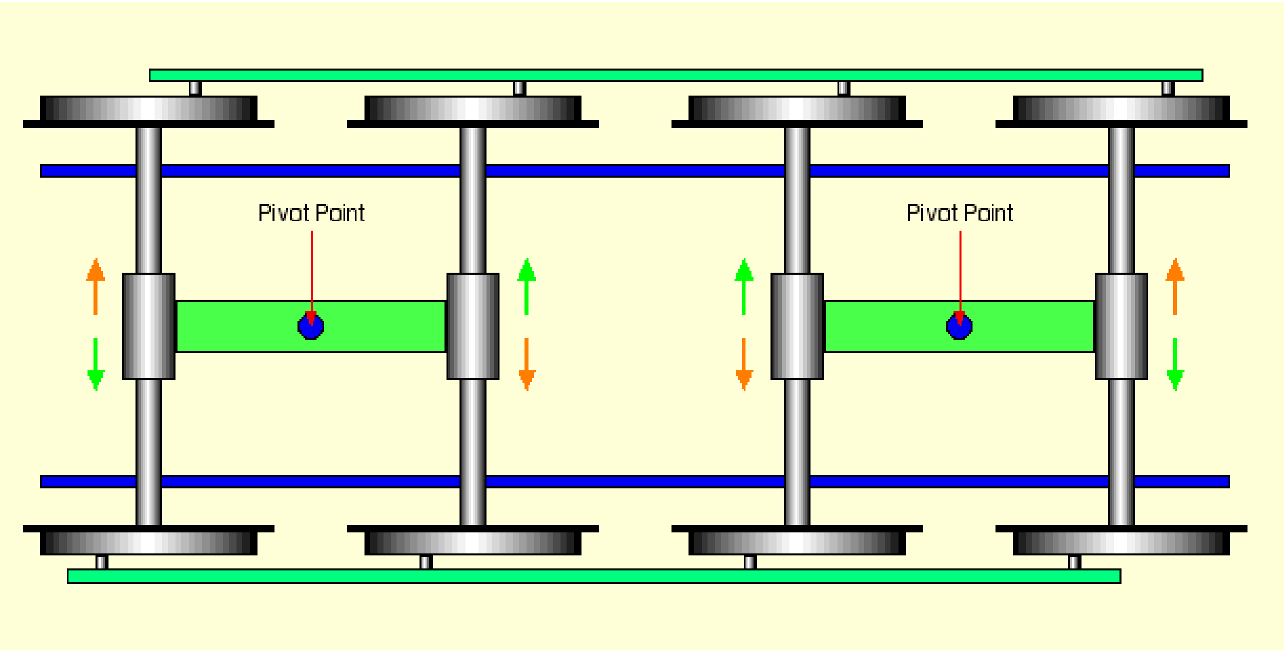
The Beugniot lever.

The Beugniot lever (Beugniot-Hebel) is a mechanical device used on a number of locomotives to improve curve running. It was named after its inventor Edouard Beugniot.

Around 1860, when Beugniot was the chief engineer at the firm of Köchlin, he developed a system whereby wheel sets are housed in pairs in the locomotive frame, with side-play, and connected by a lever. These levers are fixed to the frame in the centre and thus enable the sideways movement of the connected axles in opposite directions. In this way, instead of being fixed in the frame, the axles are able to move sideways rather like a bogie, but clearly nowhere near as much. On locomotives with a side rod drive, the axle side-play is balanced using longer coupling pins (Kuppelzapfen) on which the coupling rods are also able to move sideways.

On running round a bend, the first axle is pushed sideways by the curve of the rails and so moves the second axle parallel to it in the opposite direction, until the wheel flanges of both axles align with the rails. This distributes the guide forces between the two axles which reduces wear and tear on the wheel flanges. By enabling this transverse movement of the wheel sets, locomotives with rigid frames do not have to use the thinner wheel flanges etc. normally needed to facilitate smooth running through points, bends and tightly curved sections of track. The 'guide length' of the locomotive is formed by the distance between the two fixed Beugniot lever pivot points.

In Germany, Beugniot levers were used mainly in the middle of the 20th century. The best known examples of locomotives that use this type of lever are the MaK side-rod drive locomotives, the Class 105 and 106 engines in East Germany as well as steam locomotives like the DB Class 82.



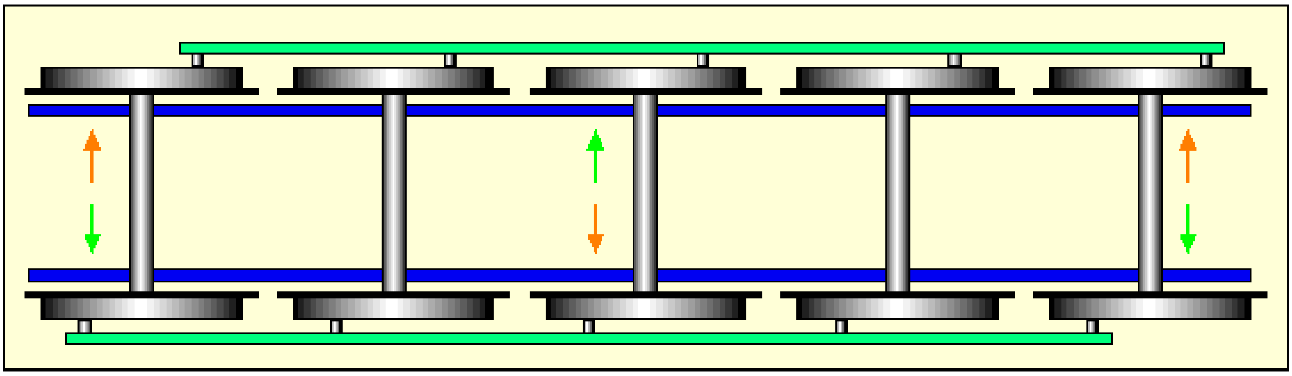
The Gölsdorf axle.

The Gölsdorf axle system is used on railway locomotives to achieve quiet running and low wear-and-tear when negotiating curves. It comprises a combination of fixed axles and axles that can slide radially, all within a single, rigid locomotive frame. The system was invented by a young Austrian locomotive builder, Karl Gölsdorf, around the end of the 19th century. The first locomotive to use this principle entered service in 1897.

In the early days of the railway, locomotives were built with more and more axles in order the meet the increasingly heavy loads of goods trains. In order not to overstress the tracks, axle loads were often restricted, initially to 16 tonnes, occasionally to 18 tonnes and later usually to 20 tonnes. A ten-coupled locomotive had to weigh no more than 100 tonnes plus whatever tonnage the leading and trailing wheels could support. The heavier a locomotive is, the more surface pressure it places on the wheels and the more it can haul. But as more and more axles are added, curve running becomes increasingly difficult. So early on, work began to develop multi-part frames and bogies which linked sets of axles to their own drive. However driving wheels within bogies using steam was a difficult task due to the moving seals that were required. As a result, a different avenue of development was pursued, whereby a degree of smooth curve running could be achieved using a long, rigid frame through the use, for example, of axles that had sufficient sideways play.

The Gölsdorf axle system avoided the need for complicated construction methods like that of Mallet locomotives. It was in effect an artifice enabling locomotives to retain a long, rigid frame (without articulation or bogies), yet whose individual axles could be better aligned when curve running. Gölsdorf axles work in this way. Two of the five axles cannot move sideways relative to the frame because their axle boxes fix them rigidly to the frame. The other axles, however, are fitted into their bearings and attached to their drives in such a way that they can be moved sideways during curve running, depending on the sideways forces acting on them. In addition the connecting and coupling rods, through which the steam pressure and linear forces from the steam pistons are translated into the rotation of the wheels via the crank pins, also have to be able to move sideways.

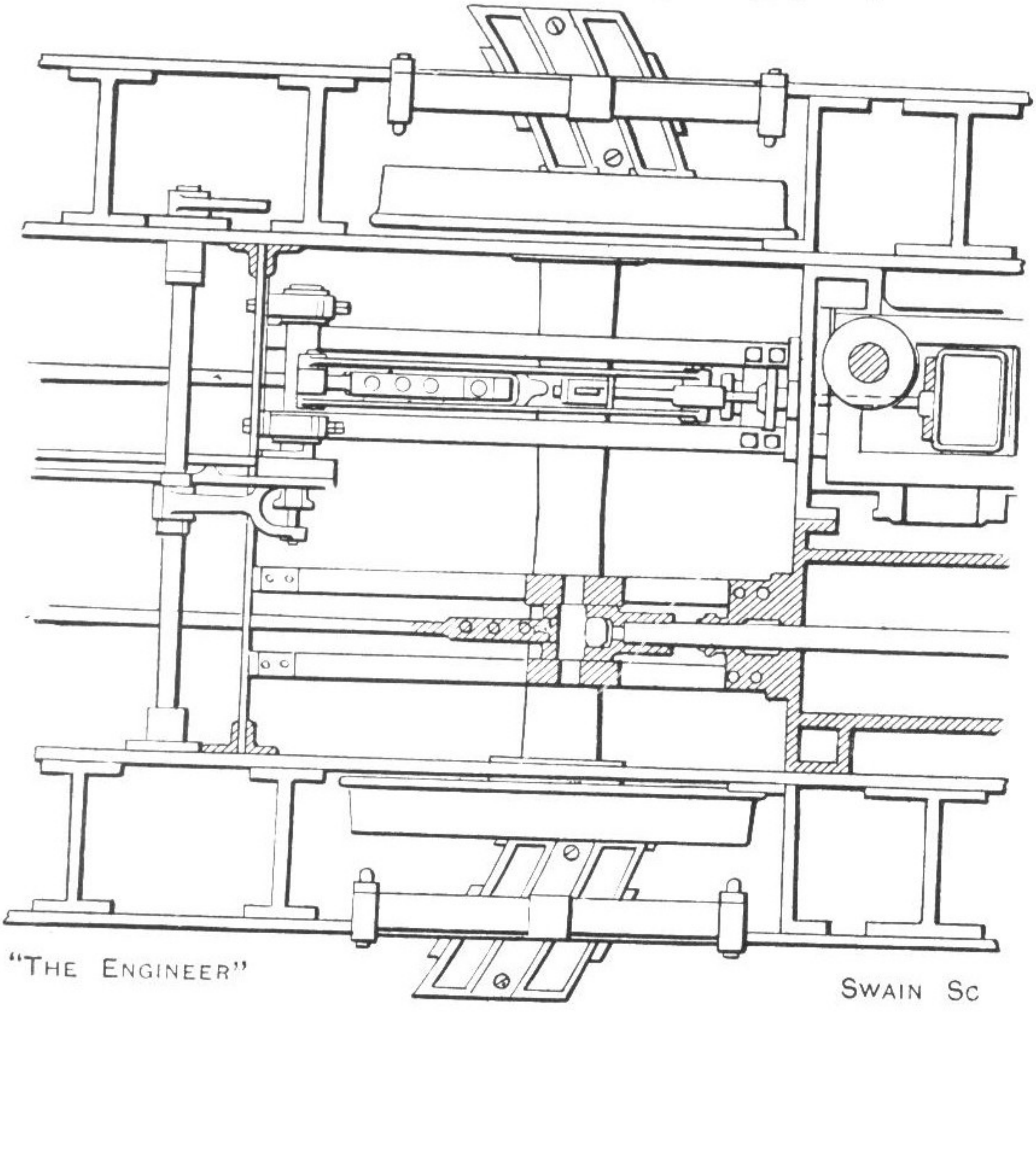
The Gölsdorf system was a standard for decades in the construction of, usually ten-coupled, occasionally twelve-coupled goods train locomotives. One of the first companies in Germany to introduce Gölsdorf axles was the privately-run Westphalian State Railway (Westfälische Landeseisenbahn), whose heavy goods trains between Belecke and Erwitte needed powerful, but nevertheless agile, locomotives in order to cross the Haarstrang mountains. From about 1910 the WLE procured and used second-hand ten-coupled engines for hauling freight trains and improved their curve running by having their running gear converted to the Gölsdorf system.



Adams axle.

The purpose of an Adams axle is to enable the wheel set of a steam locomotive to negotiate curves more easily. It is a form of radial axle, i.e. it is designed to move radially and thus can slide out to either side. This is similar to the movement of a Bissel axle. Instead of a shaft, however, an Adams axle uses an axle box that slides on an arc, the centre point of the curve being where the pivot of the imaginary shaft would be. This design, using slide bearings, is more expensive than one employing a shaft, but takes up less space.

In 1865 the Society of Engineers, London, made direct comparison between the radial axle, invented by William Bridges Adams, and a bogie design with an india-rubber central bearing invented by William Adams: During trials on the North London Railway the laterally sprung bogie was thought superior to the radial axle, but when William Adams moved from the NLR to the London and South Western Railway he adopted the design of his rival William Bridges Adams. The locomotives now known as Adams Radials are named for the LSWR Locomotive Superintendent, but they are famous for the axle invented by William Bridges Adams.

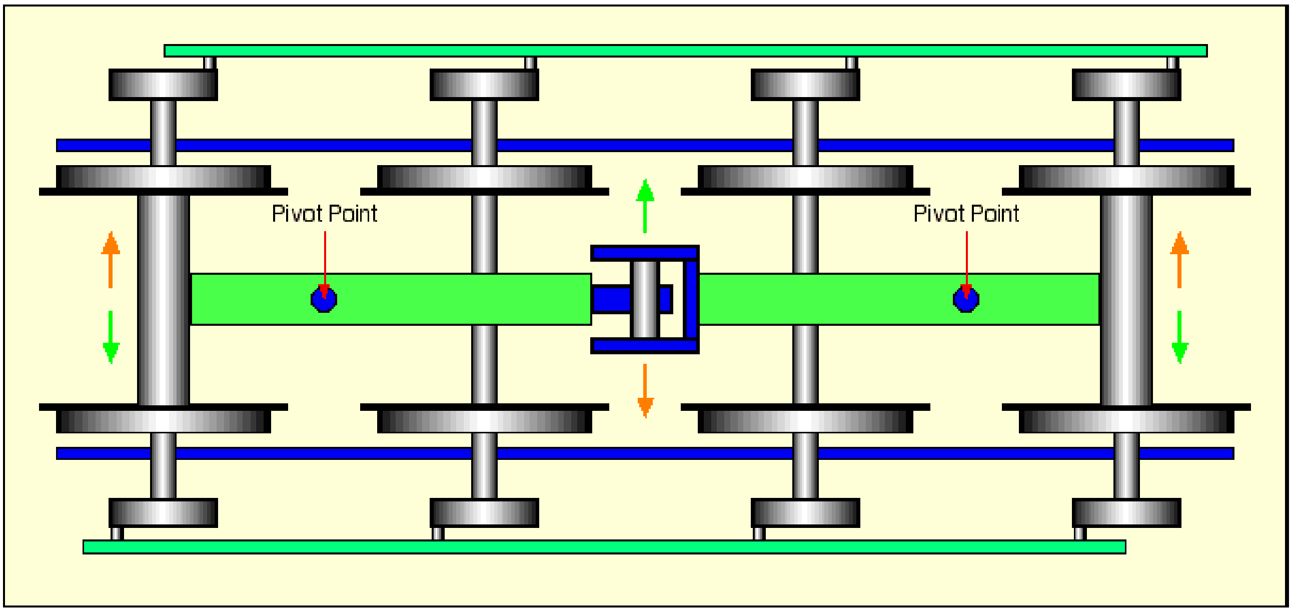


Klien-Lindner axle.

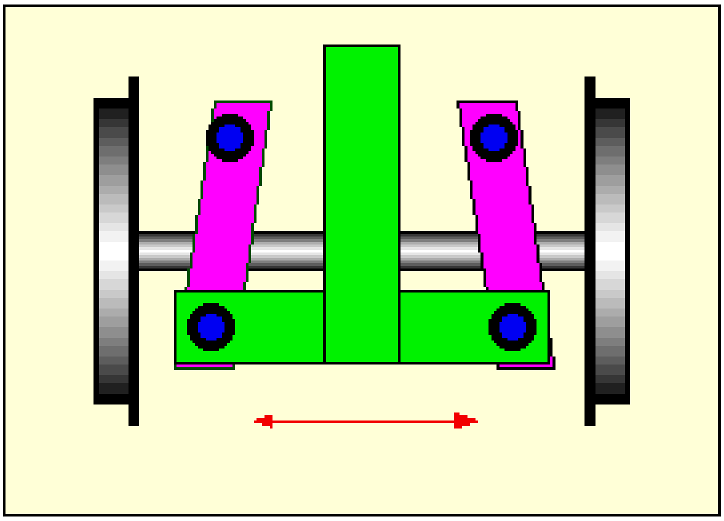
The Klien-Lindner axle (Klien-Lindner-Hohlachse) is a special type of hollow driving axle on steam locomotives that enable better curve running due to its ability to slide transversely. It was developed by the German engineers, Ewald Klien and Heinrich Lindner, of the Royal Saxon State Railways (Königlich Sächsischen Staats-Eisenbahnen). The Klien-Lindner axle uses a sort of double, or hollow, axle, one inside the other. It has a hollow axle (Hohlachse) on the outside, connected at its centre by a type of Cardan joint to a fixed driving axle running through it. The Cardan joint comprises two spherical elements that are interlinked - a solid one on the fixed axle and a hollow one on the outer hollow axle, each oriented at 90° to the other - that transfer the driving forces from the rigid axle to the hollow one. The hollow spheroid acts as a sort of link motion. In this way the hollow axle can be turned by the fixed axle. In addition the connecting link is shaped such that the axles can can slide relative to one another, parallel to their axes, to a small extent. The degree to which the hollow axle can swivel is set by the outer diameter of the fixed axle and the internal diameter of the hollow one.

This system is used on steam locomotives with fixed outer frames and coupled axles. Typically the conventionally driven wheels are in the centre and there are outer Klien-Lindner axles, front and rear. In this way the wheels, which are fixed to the hollow axles, are 'steered' by shafts that pivot on the frame when the locomotive is curve running. Coupling rods from the conventional driving wheels in the centre act on drive cranks on the inner axles fixed to the frame.

In spite of their relatively simple design Klien-Lindner axles were not widely used. Derailments were common when they were used as leading axles. The axles often caused uneven, jerky running as a result of the resistance forces that arise from this type of Cardan joint, and they were expensive to maintain, something which was not offset by the reduced wear and tear on wheel flanges and rails.



The Swinging Arm Bogie.



The Swinging arm bogie allows the front bogie to move in a lateral motion but does not allow any longitudinal or rotational motion. There is no resistive elastic forces used as the weight of the loco on the bogie provides the centring force.

The Pony Truck.

The design uses a single-axled bogie, usually known as a pony truck, whose pivot is towards the centre of the locomotive.