Railway Systems Engineering

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Introduction

Railway systems engineering is a multi-faceted engineering discipline dealing with the design, construction and operation of all types of railway systems. It encompasses a wide range of engineering disciplines, including Civil engineering, Computer engineering, Electrical engineering, Mechanical engineering, Industrial engineering and Production engineering. A great many other engineering sub-disciplines are also called upon.

History

With the advent of the railways in the early nineteenth century, a need arose for a specialized group of engineers capable of dealing with the unique problems associated with Railway engineering. As the railways expanded and became a major economic force, a great many engineers became involved in the field, probably the most notable being Richard Trevithick, George Stephenson and Isambard Kingdom Brunel. Today, railway systems engineering continues to be a vibrant field of engineering, with many major projects such as the Channel Tunnel in progress.

Subfields

- Command, Control & Signaling

  Office Systems Design
  Data Center Design
  SCADA
  Network Design

- Energy Electrification

  Third Rail
  Overhead Contact System

- Infrastructure Permanent Way engineering

- Light rail systems
- On-track plant
- Rail Systems Integration
- Train control systems
- Railway Vehicle Engineering
- Wheel-rail interface
- Systems Engineering

  Fare Collection
  CCTV
  Public Address
  Intrusion Detection
  Access Control

- Systems Integration

Chapter 1

Railroad Engineer

A railroad engineer's workplace on a German ICE-Train

A **railroad engineer**, **locomotive engineer**, **train operator**, **train driver** or **engine driver** is a person who drives a train on a railroad. The engineer is in charge of and responsible for the locomotive(s) as well as the mechanical operation of the train, train speed, and all train handling.

On many US railroads, the career progression is one that starts as an assistant (brakeman), conductor and finally, engineer. In the United States the engineer is required to be certified and re-certified every 2–3 years.

In India, an engine driver starts as a *Diesel Assistant* or *Electrical Assistant* (in case of electric locomotives). They then get promoted on a scale: B, A, and A Special. An 'A Special' driver drives the faster, more important trains.

In the United States, Canada, and New Zealand, train drivers are known as "locomotive engineers". In the United Kingdom, South Africa, and Australia, they are known as "train drivers", "engine drivers", "locomotive drivers", or "locomotive operators".

Duties

The cab of a CountryLink Xplorer diesel multiple unit

An engineer is responsible for preparing equipment for service, checking paperwork and the condition of the locomotives. Their duties require that they control acceleration, braking and handling of the train underway. They must know the physical characteristics of the railroad, including passenger stations, the incline and decline of the right-of-way and speed limits. Along with the conductor, the engineer monitors time to not fall behind schedule, nor leave stations early. The train's speed must be reduced when following other trains, approaching route diversions, or regulating time over road to avoid arriving too early. The engineer assumes the duties of the conductor if the conductor is incapacitated.

The locomotive engineer is required to have an intimate knowledge of track geometry including signal placement so as to be able to safely control their train.

Maintaining concentration is of critical importance in this role.

Train handling

A workplace in Rigi cogwheel electric train

Train dynamics can be extreme and therefore an engineer must be familiar with train handling techniques so as to avoid train partings, derailments and not exceeding line speed.

Freight trains typically have different train forces from passenger trains. A typical freight train may have 500 tonnes of locomotive weight at the front. That may be followed by 1500m of wagons. The wagons may or may not be uniformly loaded and may brake differently.

Severe brake applications can combine with these factors to cause a train parting. Therefore good train handling practice for freight trains is usually to keep the consist (rail vehicles which make up a train) stretched. This is achieved by keeping the consist in power while a brake application is made and by bleeding the air off the locomotives brakes before they apply. It is not possible to do this with the use of dynamic brake, which presents its own train handling challenges.

When there are multiple locomotives, some may be set up to brake like wagons instead of locomotives, as too many locomotives on the front of the train (all with brakes bled off) would require too heavy an application from the rest.

On shorter passenger trains, this is even more noticeable, requiring the first application of the brake to be bled off on the locomotive, applying locomotive brakes with subsequent increases in application. The length and make-up of the slowing or stopping distance dictates just how much locomotive brake application should be allowed to apply.

The use of dynamic brake can result in a severe slack action, When engaged run in is highly possible if brought in at an inappropriate time (regarding track geometry and train speed) and if disengaged at an inappropriate time can result in a run out. Both can potentially snap train drawgear.

Straightlining is a potential cause of derailment that train handling techniques must take into account in order to reduce the likelihood of occurrence. When a train rounds a curve basic physics dictates the trailing wagons in the consist will try to take the shortest route and the flange on some of the wheels within the consist could potentially fail to prevent this occurring with the resultant effect being a derailment.

Track geometry is also critical to train handling. It is desirable to have brakes releasing at the bottom of steep grades rather than applied. And at the top of a steep grade it is desirable to have a fully charged brake pipe.

Serial braking is where a train descends a grade on the air brake alone. The brake pipe application is gradually increased to slow down and if required (depending on the weight of the train and on the grade) stop the train so as to allow the locomotive compressors to recharge the brake pipe throughout the consist. In these cases it is permissible to use the locomotive brakes (which are independent of the train brake and charged through the main reservoir directly) to hold the train (In some cases the weight of the trailing consist will not be held on the locomotive brakes alone) slowing the rate of acceleration and giving more time to recharge the brake pipe to give a better application in the next subsequent train brake application. A runaway can occur if a brake application is required before the train pipe has recharged (as happened at Cima Hill in the United States).

A split reduction is where a train brake application is made and gradually increased as the train descends the grade. It is different to serial braking in that with Serial Braking the application is released, the brake pipe recharged then reapplied.

The dynamic brake when operable slows down the rate of acceleration and allows longer for a train brake pipe to be recharged before being required to be re applied. When a train descends a grade utilizing both the dynamic and air brakes the procedure is known as 'maintaining braking'.

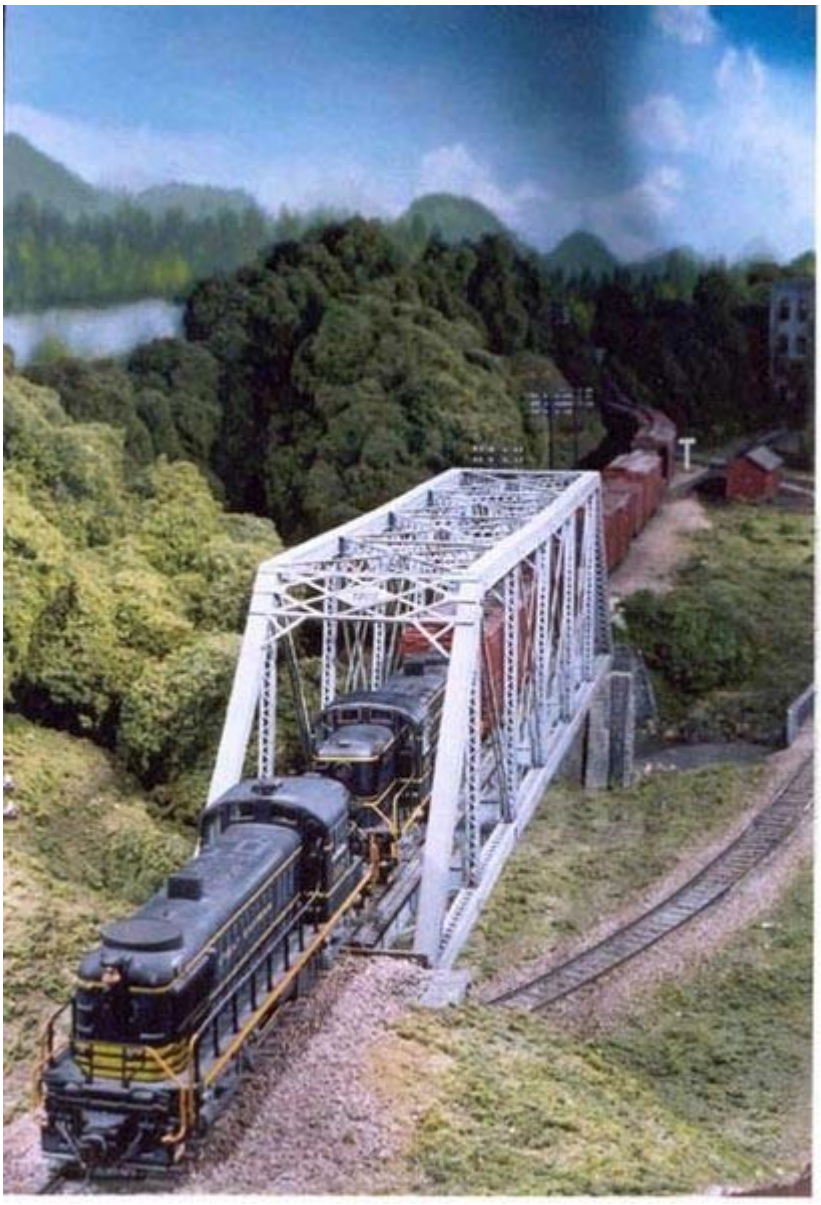
In the case of severe grades (for example the Westmere Bank in New Zealand, which is a 1:33 grade with a 40 km/h (25 mph)speed limit) a trains allowable speed is lower for a train that doesn't have dynamic brake than for one that does.

In freight train marshalling yards the wagon brakes are sometimes bled off so they can be easily loose shunted. However when a shunt locomotive moves large numbers of wagons

around with no brakes the locomotive must brake for the entire train. This can result in severe slack action and wheel slip. Damage to goods and rolling stock is possible. Also, with unbraked wagons there is potential for a runaway.

Chapter 2

Rail Transport Modelling



HO scale model railroad.

A scale model of Berlin's Bahnhof Zoo at the LOXX Berlin model railway.

A Japanese HOe scale model railroad.

The Miniatur Wunderland in Hamburg/Germany - the largest model railway in the world.

One of the smallest (Z scale, 1:220) placed on the buffer bar of one of the largest (live steam, 1:8) model locomotives.

HO scale (1:87) model of a North American center cab switcher shown with a pencil for size.

Z scale (1:220) scene of a 2-6-0 steam locomotive being turned with a scratch-built Russell snow plow parked on a stub (Val Ease Central Railroad).

Railway modelling (UK, Australia, Ireland and Canada) or **model railroading** (US) is a hobby in which rail transport systems are modelled at a reduced scale. The scale models

include locomotives, rolling stock, streetcars, tracks, signalling, and roads, buildings, vehicles, model figures, lights, and features such as streams, hills and canyons.

The earliest model railways are the 'carpet railways' in the 1840s. Electric trains appeared around the turn of the 20th century. But these were crude likenesses. Model trains today are more realistic. Today modellers create model railway / railroad layouts, often recreating real locations and periods in history.

General description

Involvement ranges from possession of a train set to spending hours and large sums on a large and exacting model of a railroad and the scenery through which it passes, called a "layout". Hobbyists, called "model railroaders" or "railway modellers", may maintain models large enough to ride. Modellers may collect model trains, building a landscape for the trains to pass through, or operate their own railroad in miniature.

Some older scale models reach high prices.

Layouts vary from a circle or oval of track to realistic, real places modeled to scale. One of the largest is in the Pendon Museum in Oxfordshire, UK, where an EM gauge (same 1:76.2 scale as 00 but with more accurate track gauge) model of the Vale of White Horse in the 1930s is under construction. The museum also houses one of the earliest scenic models - the Madder Valley layout built by John Ahern. This was built in the late 1930s to late 1950s and brought in realistic modelling, receiving coverage on both sides of the Atlantic in the magazines *Model Railway News* and *Model Railroader*. Bekonscot in Buckinghamshire is the oldest model village and includes a model railway, dating from the 1930s. The world's largest model railroad in H0 scale is the Miniatur Wunderland in Hamburg, Germany. The largest live steam layout, with 25 miles (40 km) of track is *Train Mountain* in Chiloquin, Oregon, U.S..

Model railroad clubs exist where enthusiasts meet. Clubs display models for the public. One specialist branch concentrates on larger scales and gauges, commonly using track gauges from 3.5 to 7.5 inches (89 to 191 mm). Models in these scales are usually hand-built and powered by live steam, or diesel-hydraulic, and the engines are often powerful enough to haul dozens of human passengers. Often railways of this size are called miniature railways. List of model railroad clubs.

The Tech Model Railroad Club (TMRC) at MIT in the 1950s pioneered automatic control of track-switching by using telephone relays.

The oldest society is The Model Railway Club (established 1910), near Kings Cross, London, UK. As well as building model railways, it has 5,000 books and periodicals. Similarly, The Historical Model Railway Society at Butterley, near Ripley, Derbyshire specialises in historical matters and has archives available to members and non-members.

Scales and gauges

The size of engines depends on the scale and can vary from 700 mm (27.6 in) tall for the largest ridable live steam scales such as 1:8, down to matchbox size for the smallest in Z-scale (1:220). However, there is another scale that was introduced in 2007 that is also commercially available. Called T Gauge, it is 3 mm (0.118 in) gauge track and is a scale of 1:450, basically half the size of Z scale. A typical H0 (1:87) engine is 50 mm (1.97 in) tall, and 100 to 300 mm (3.94 to 11.81 in) long. The most popular scales are: G gauge, Gauge 1, O gauge, S scale, HO gauge (in Britain, the similar 00), TT scale, and N scale (1:160 in the United States, but 1:144 in the UK). There is growing interest in Z scale and T Gauge. HO and OO are the most popular. Popular narrow-gauge scales include Sn3, HOn3 Scale and Nn3, which are the same in scale as S, H0 and N except with a narrower spacing between the tracks (in these examples, a scale 3 ft (914 mm) instead of the 4 ft 8 ½ in (1,435 mm) standard gauge).

The largest common scale is 1:8, with 1:4 sometimes used for park rides. G scale (Garden, 1:24 scale) is most popular for backyard modelling. It is easier to fit a G scale model into a garden and keep scenery proportional to the trains. Gauge 1 and Gauge 3 are also popular for gardens. O, S, HO, and N gauge are more often used indoors. Lionel trains in 0 scale (1:48 scale) are popular toys. S refers to 1:64 scale.

The words *scale* and *gauge* seem at first interchangeable but their meanings are different. *Scale* is the model's measurement as a proportion to the original, while *gauge* is the measurement between the rails.

At first, model railways were not to scale. Manufacturers and hobbyists soon arrived at *de facto* standards for interchangeability, such as gauge, but trains were only a rough approximation to the real thing. Official scales for the gauges were drawn up but not at first rigidly followed and not necessarily correctly proportioned for the gauge chosen. O (zero) gauge trains, for instance, operate on track too widely spaced in the United States as the scale is accepted as 1:48 whereas in Britain 0 gauge uses a ratio of 43.5:1 or 7 mm/1 foot and the gauge is near to correct. British 00 standards operate on track significantly too narrow. The 4 mm/1 foot scale on a 16.5 mm (0.650 in) gauge corresponds to a track gauge of 4 ft 1 ½ in/1,257 mm, 7 inches / 178 millimetres undersized). 16.5 mm (0.650 in) gauge corresponds to 4 ft 8 ½ in (1,435 mm) standard gauge in H0 (half zero) 3.5 mm/1 foot or 1:87. Most commercial scales have standards that include wheel flanges that are too deep, wheel treads that are too wide, and rail tracks that are too large.

Later, modellers became dissatisfied with inaccuracies and developed standards in which everything is correctly scaled. These are used by modellers but have not spread to mass-production because the inaccuracies and overscale properties of the commercial scales ensure reliable operation and allow for shortcuts necessary for cost control. The finescale standards include the UK's P4, and the even finer S4, which uses track dimensions scaled from the prototype. This 4 mm:1 ft modelling uses wheels 2 mm (0.079 in) or less wide

running on track with a gauge of 18.83 mm (0.741 in). Check-rail and wing-rail clearances are similarly accurate.

A compromise of P4 and 00 is 'EM' which uses a gauge of 18.2 mm (0.717 in) with more generous tolerances than P4 for check clearances. It gives a better appearance than 00 though pointwork is not as close to reality as P4. It suits many where time and improved appearance are important.

Couplers and connectors

In addition to different scales, there are also different types of couplers for connecting cars, which are not compatible with each other.

In H0, the Americans standardized on horn-hook, or X2F couplers, though these have largely given way to working knuckle couplers (Kadee) which are a close approximation to the "automatic" couplers used on the prototype there and elsewhere. Also in H0, the European manufacturers have standardized, but on a coupler mount, not a coupler: many varieties of coupler can be plugged in (and out) of the NEM coupler box. None of the popular couplers has any resemblance to the prototype three-link chains generally used on the continent. For English modelers, whose most popular scale is 00, the normal coupler is a tension-lock coupler, which, again has no pretense of replicating the usual prototype three-link chain couplers.

Other scales have similar ranges of non-compatible couplers available.

It must be emphasized that, in all scales, couplers can be exchanged, with varying degrees of difficulty.

Landscaping

A HOe scale layout, 47 × 32 cm (18.5 × 12.6 in) in size.

The landscape in this N scale town includes weathered buildings and tall uncut grass.

Some modellers pay attention to landscaping their layout, creating a fantasy world or modelling an actual location, often historic. Landscaping is termed "scenery building" or "scenicking".

Constructing scenery involves preparing a sub-terrain using a wide variety of building materials, including (but not limited to) screen wire, a lattice of cardboard strips, or carved stacks of expanded polystyrene (styrofoam) sheets. A scenery base is applied over the sub-terrain; typical base include casting plaster, plaster of Paris, hybrid paper-pulp (papier-mâché) or a lightweight foam/fiberglass/bubblewrap composite as in Geodesic Foam Scenery. The scenery base is covered with ground cover, which may be ground foam, colored sawdust, natural lichen, or commercial scatter materials for grass and shrubbery. Buildings and structures can be purchased as kits, or built from cardboard, balsa wood, basswood, paper, or polystyrene or other plastic. Trees can be fabricated from materials such as Western sagebrush, candytuft, and caspia, to which adhesive and model foliage are applied; or they can be bought ready-made from specialist maunfacturers. Water can be simulated using polyester casting resin, polyurethane, or rippled glass. Rocks can be cast in plaster or in plastic with a foam backing. Castings can be painted with stains to give coloring and shadows.

Weathering

Weathering refers to making a model look used and exposed to weather by simulating dirt and wear on real vehicles, structures and equipment. Most models come out of the box looking new, because unweathered finishes are easier to produce and many collectors want models to look pristine. Also, the wear a freight car or building undergoes depends not only on age but where it is used. Rail cars in cities accumulate grime from building and automobile exhaust, while cars in deserts may be subjected to sandstorms which etch or strip paint. A model that is weathered would not fit as many layouts as a pristine model which can be weathered by its purchaser.

Weathering purchased models is common. At the least, weathering aims to reduce the plastic-like finish of scale models. The simulation of grime, rust, dirt, and wear add realism. Some modelers simulate fuel stains on tanks, or corrosion on battery boxes. In some cases, evidence of accidents or repairs may be added, such as dents or freshly-painted replacement parts, and weathered models can be nearly indistinguishable from their prototypes when photographed appropriately.

Methods of power

The sugar-cube sized electric motor in a Z scale model locomotive. The entire engine is only 50 mm (2") long.

Model of WP Steam Locomotive(1:3 size) at Guntur, India.

Model railway engines are generally operated by low voltage DC electricity supplied via the tracks, but there are exceptions, such as Märklin and Lionel Corporation, which use AC.

Most early models for the toy market were powered by clockwork and controlled by levers on the locomotive. Although this made control crude the models were large and robust enough that grabbing the controls was practical. Various manufacturers introduced slowing and stopping tracks that could trigger levers on the locomotive and allow station stops. Other locomotives, particularly large models, used steam. Steam or clockwork driven engines are still sought by collectors.

Early electrical models used a three-rail system with the wheels resting on a metal track with metal sleepers that conducted power and a middle rail which provided power to a skid under the locomotive. This made sense at the time as models were metal and conductive. Modern plastics were not available and insulation was a problem. In addition the notion of accurate models had yet to evolve and toy trains and track were crude tinplate.

As accuracy became important some systems adopted two-rail power in which the wheels were isolated and the rails carried the positive and negative supply or two sides of the AC supply. Other systems such as Märklin instead used fine metal studs to replace the central rail, allowing existing three-rail models to use more realistic track.

Although DC with the positive and negative charges on the two rails is the most common method, Märklin and Lionel use AC on the three-rail system. American Flyer used AC power on two-rail track.

Early electric trains ran on batteries because few homes in the late 19th and early 20th centuries had electricity. Today, inexpensive train sets on batteries are again common but regarded as toys seldom used by hobbyists. Battery power is used by many garden railway and larger scale systems because of the difficulty in obtaining reliable power supply through the rails outdoors and because the high power consumption and thus current draw of large scale garden models is more easily and safely met with lead acid batteries.

Engines powered by Live steam are often built in large, outdoor gauges, and are available in Gauge 1, G scale, 16 mm scale and can be found in 0 and H0. Hornby Railways produce live steam locomotives in 00, based on designs first arrived at by an amateur modeller. Other modellers have built live steam models in H0/00, 009 and N, and there is one in Z in Australia.

Occasionally gasoline-electric models, patterned after real diesel-electric locomotives, come up among hobbyists and companies like Pilgrim Locomotive Works have sold such locomotives. Large-scale petrol-mechanical and petrol-hydraulic models are available but unusual and pricier than the electrically powered versions.

Scratch building

Modern manufacturing techniques mean mass produced models achieve a high degree of precision and realism. In the past this was not the case and scratch building was very common. Simple models are made using cardboard engineering techniques. More sophisticated models can be made using a combination of etched sheets of brass and low temperature castings. Parts that need machining, such as wheels and couplings are bought in. Etched kits are still popular, still accompanied by low temperature castings. These kits produce models that are not covered by the major manufacturers or in scales that are not in mass production. Laser machining techniques have extended this ability to thicker materials for scale steam and other locomotive types.

Control

Coin-operated model train layout in Germany

The first clockwork (spring-drive) and live steam locomotives ran until out of power, with no way for the operator to stop and restart the locomotive or vary its speed. The advent of electric trains, which appeared commercially in the 1890s, allowed control of the speed by varying the current or voltage. As trains began to be powered by transformers and rectifiers more sophisticated throttles appeared, and soon trains powered by AC contained mechanisms to change direction or go into neutral gear when the operator cycled the power. Trains powered by DC can change direction by reversing polarity.

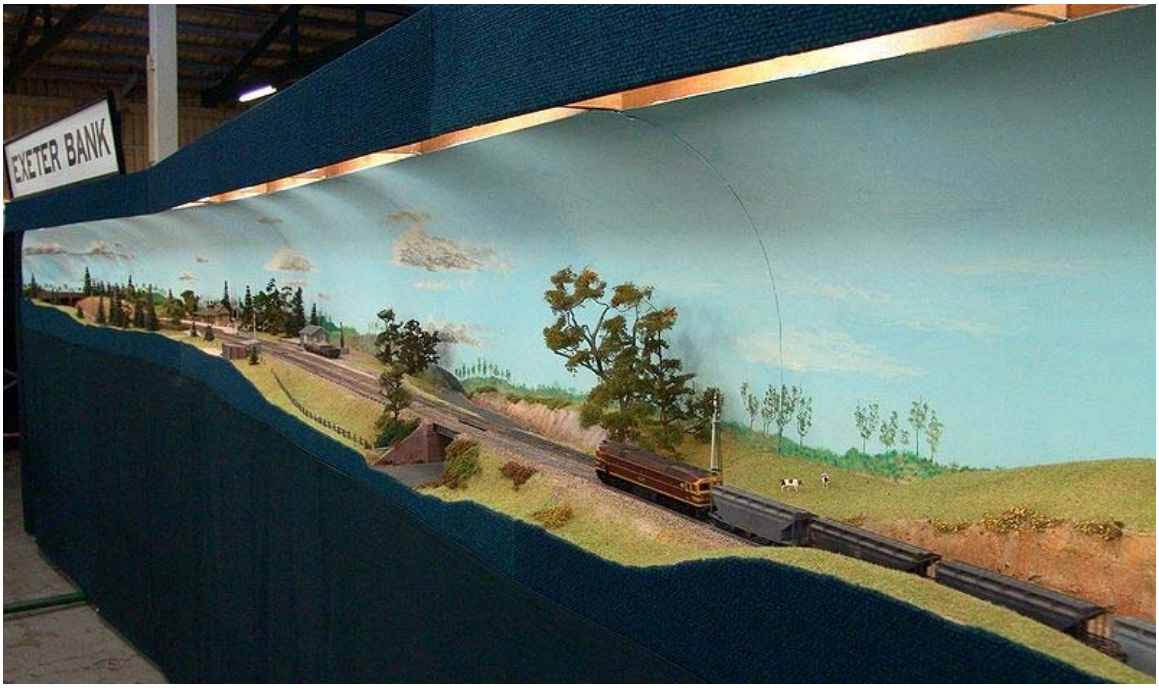
Electricity permits control by dividing the layout into isolated blocks, where trains can be slowed or stopped by lowering or cutting power to a block. Dividing a layout into blocks permitted operators to run more than one train with less risk of a fast train catching and hitting a slow train. Blocks can also trigger signals or other accessories, adding realism or whimsy. Three-rail systems often insulate one of the common rails on a section of track, and use a passing train to complete the circuit and activate an accessory.

Many modern railways are computer-controlled. The industry standard command system is Digital Command Control (DCC). The advantages to DCC are that instead of controlling the voltage to the track, small circuit cards, or decoders, hidden inside the

piece of equipment allowing control of the individual locomotive. This allows more realistic operation, in that the modeler can control individual locomotives on the same stretch of track. Some DCC decoders generate sounds through a speaker also hidden inside. Less common closed proprietary systems also exist.

In large scales, particularly for garden railways, radio control and DCC in the garden has become popular.

Model railway manufacturers



Exeter Bank: An HO-scale Australian model railway

An O-scale Australian model railway

A propane fired 1:8 scale live steam train running on the Finnish Railway Museum's miniature track.

A model train running on the Willans Hill Model Railway miniature track in Wagga Wagga, New South Wales, Australia.

- Airfix
- American Flyer
- AR Kits
- Arnold
- Athearn
- Atlas Model Railroad
- Auhagen
- Bachmann Industries
- Bassett-Lowke
- Bavaria
- Bemo
- Bing
- Bowser Manufacturing
- Bachmann
- Broadway Limited Imports (BLI)
- Dapol
- Exley
- Faller
- Ferris (defunct)
- Lesney (Matchbox)
- Lehmann Gross Bahn
- Life Like
- Lima
- Lionel
- Marx
- Mainline
- Mantua, later Tyco Toys
- Märklin
- Mehano
- Merkur (toy)
- Merten
- Modemo (Hasegawa)
- MTH Electric Trains
- Noch
- Peco
- Piko
- Playmobil
- President's Choice

- Fleischmann
- Fulgurex
- G .& R. Wrenn Ltd
- Graham Farish ("Grafar")(Owned by Bachmann Branchline)
- Great West Models
- HAG
- Heljan
- Herpa
- Hornby
- Ibertren
- JMRI
- Jouef
- Kato
- Kemtron Corporation (defunct 1964)
- Klein Modellbahn
- Kleinbahn
- Lego
- Lemaco
- Rapido
- Rivarossi
- Roco
- Rocrail
- Rokal
- Tomix
- Tillig
- Tri-ang Railways
- Trix/Minitrix
- USA Trains
- Varney
- Viessmann
- Vollmer
- Walthers
- Williams
- Woodland Scenics
- Worsley Works

Famous model railroaders

Model train display at Chicago's Museum of Science and Industry

A model railway based on a fictional location in the United States.

Layout standards organizations

Several organizations exist to set standardizations for connectability between individual layout sections (commonly called "modules"). This is so several (or hundreds, given enough space and power) people or groups can bring together their own modules, connect them together with as little trouble as possible, and operate their trains. Despite different design and operation philosophies, different organizations have similar goals; standardized ends to facilitate connection with other modules built to the same specifications, standardized electricals, equipment, curve radii.

- NTRAK, standardized 3-track (heavy operation) mainline with several optional branchlines. Focuses on Standard Gauge, but also has specifications for Narrow Gauge. Due to its popularity, it can be found in regional variations, most notably the Imperial-to-Metric measurement conversions. Tends to be used more for 'unattended display' than 'operation'.
- FREMO, a European-based organisation focusing on a single-track line, HO Scale. Also sets standards for N Scale modules. Standards are considerably more flexible in module shape than NTRAK, and has expanded over the years to accommodate several scenery variations.
- oNeTRAK, operationally similar to FREMO, standardises around a single-track mainline, with modules of varying sizes and shapes. Designed with the existing NTRAK spec in mind, is fully compatible with such modules.
- Z-Bend Track, uses a double track mainline running down both sides of a module. Modules can be of any length, or width in the middle and any overall shape. The

"standard" called Z-Bend Track only applies to the last five inches (12.7 cm) of the module's interface to other modules, the electrical interface and the module height.

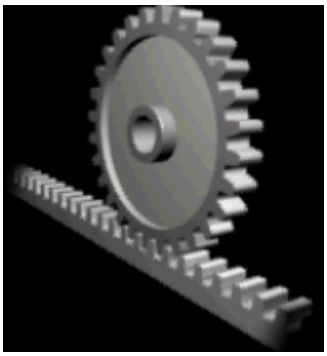
- ausTRAK, N Scale, two-track main with hidden third track (can be used as NTRAK's third main, as a return/continuous loop, or hidden yard/siding/on-line storage). Australian scenery and rolling stock modelled in Standard Gauge.
- NMRA, National Model Railroad Association, the largest organization devoted to the development, promotion, and enjoyment of the hobby of model railroading.
- MOROP, European Union of Model Railroad and Railroad Fans, the European standardization organisation.
- sTTandard, Polish TT-scale (1:120) modules organization.
- N-orma, Polish N-scale (1:160) modules organization.

Chapter 3

Rack Railway

Rack railway track using the Lamella system rack.

Schneeberg cog railway steam locomotive, with tilted boiler, on level track.



functioning of the rack and pinion.

A **rack-and-pinion railway** (also **rack railway**, **cog railway**) is a railway with a toothed rack rail, usually between the running rails. The trains are fitted with one or more cog wheels or pinions that mesh with this rack rail. This allows the trains to operate on steep gradients.

Most rack railways are mountain railways, although a few are transit railways or tramways built to overcome a steep gradient in an urban environment.

The first cog railway was the Middleton Railway between Middleton and Leeds in West Yorkshire, England, UK, where the first commercial steam locomotive, *Salamanca*, ran in 1812. This used a rack and pinion system designed and patented in 1811 by John Blenkinsop.

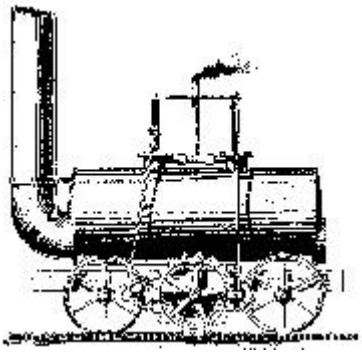
The first mountain cog railway was the Mount Washington Cog Railway in the US state of New Hampshire, which carried its first fare-paying passengers in 1868 and reached the summit of Mount Washington in 1869. The first mountain rack railway in continental Europe was the Vitznau-Rigi-Bahn on Mount Rigi in Switzerland, which opened in 1871. Both lines are still running.

Rack systems

Different rack systems: from the left, Riggenbach, Strub, Abt and Locher.

A number of different rack systems have been developed. Today, the majority of rack railways use the Abt system.

Blenkinsop



Blenkinsop rack and pinion with teeth on outer side of one rail only

Thinking that the friction of metal wheels on metal rails would be too low, John Blenkinsop built his locomotives for the Middleton Railway in 1812 with a 20 teeth, 3 feet (915 mm) diameter cog wheel (pinion) on the left side that engaged in rack teeth (two teeth per foot) on the outer side of the rail, the metal "fishbelly" edge rail with its side rack being cast all in one piece, in three feet (one yard) lengths. While Blenkinsop's system remained in use for 25 years on the Middleton Railway, it remained a curiosity because simple friction was found to be sufficient for railroads operating on level ground. One wonders how the Blenkinsop rack dealt with pointwork.

With the exception of some early Morgan rack installations, all other rack systems place the rack rail halfway between the running rails.

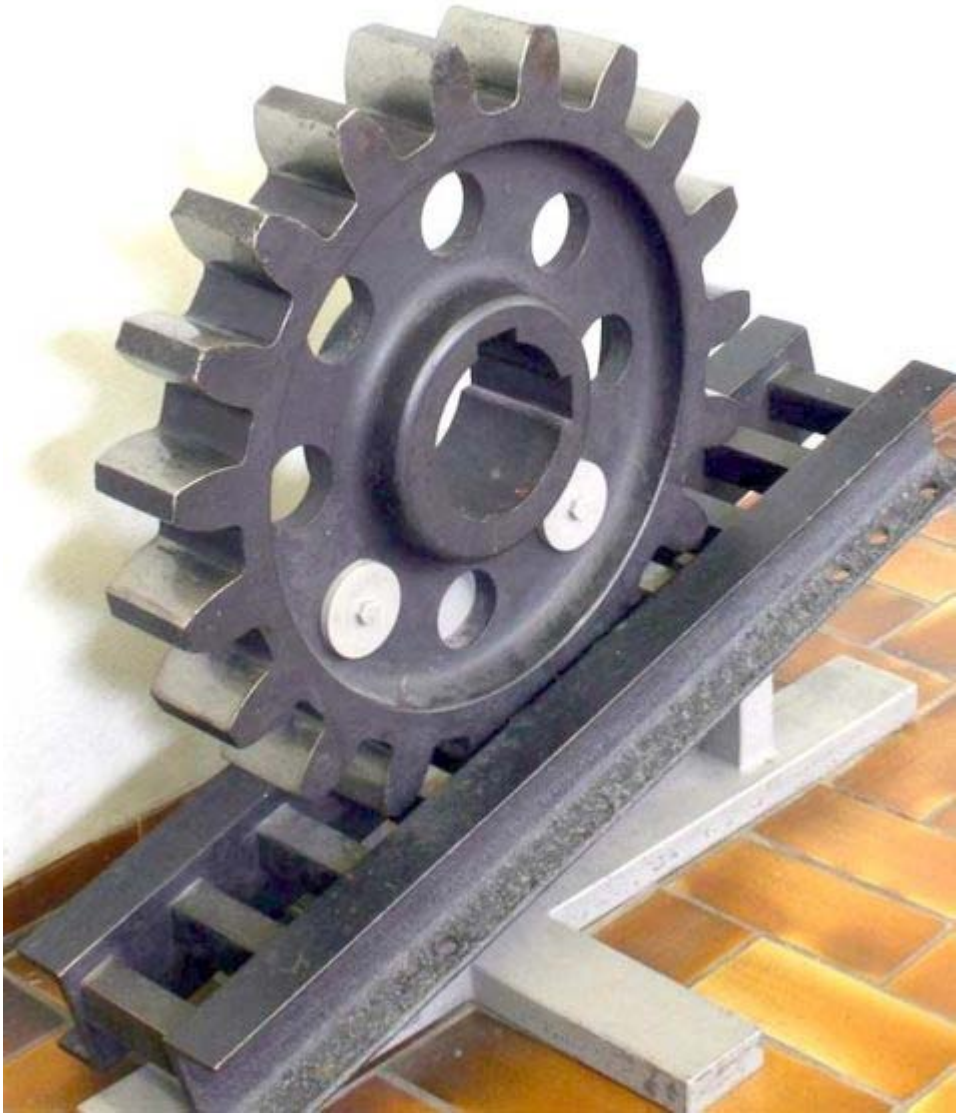
Stephenson

George Stephenson grouped the steep gradients on either side of Rainhill and from Liverpool down to the wharfs, just in case cable haulage was necessary. In the event, only the wharf line needed cable haulage for a few decades.

Marsh

The first successful rack railway in the US was the Mount Washington Cog Railway, developed by Sylvester Marsh. Marsh was issued a U.S. patent for the general idea of a rack railway in September 1861, and in January 1867 for a practical rack where the gear teeth take the form of rollers arranged like the rungs of a ladder between two L-shaped wrought-iron rails. The first public trial of the Marsh rack on Mount Washington was made on August 29, 1866, when only one quarter of a mile (half a kilometer) of track had been completed. The Mount Washington railway opened to the public on August 14, 1868. The pinion wheels on the locomotives had deep teeth that ensure that at least two teeth are engaged with the rack at all times - this measure helps reduce the possibility of the pinions riding up and out of the rack.

Riggenbach



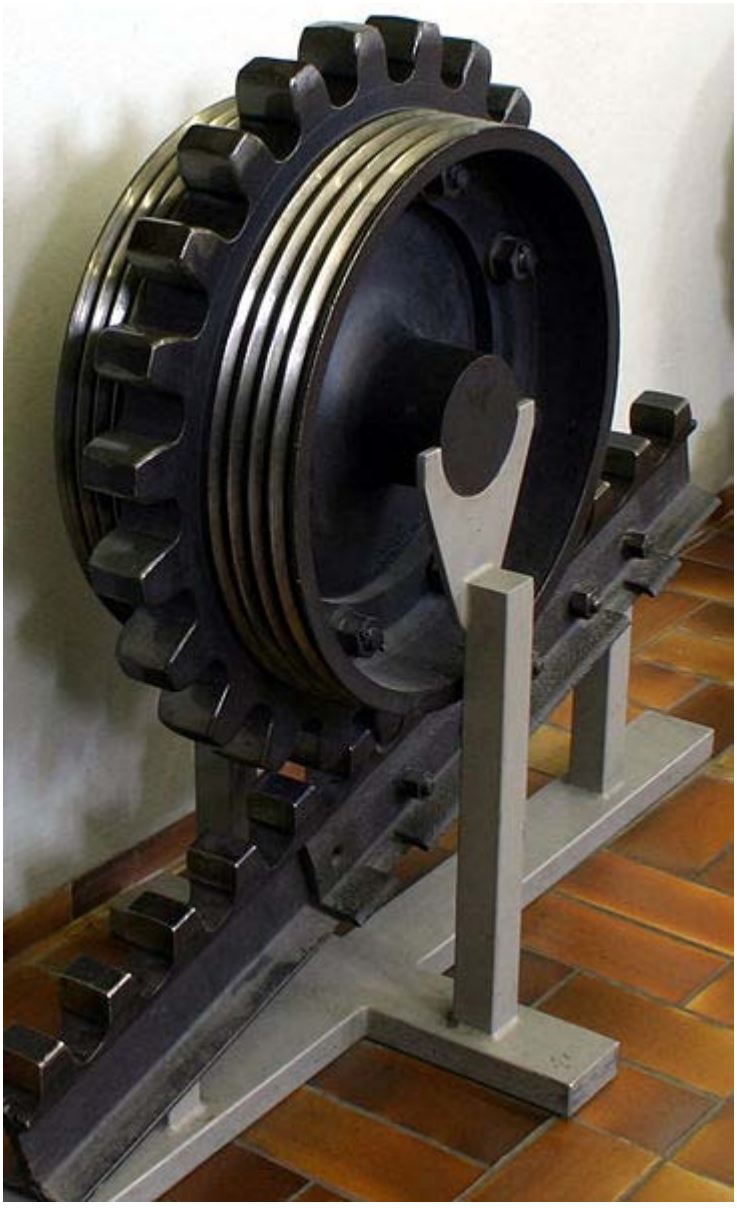
The Riggenbach rack system

The Riggenbach rack system was invented by Niklaus Riggenbach working at about the same time as, but independently from Marsh. Riggenbach was granted a French patent in 1863 based on a working model which he used to interest potential Swiss backers. During this time, the Swiss Consul to the United States visited Marsh's Mount Washington Cog Railway and reported back with enthusiasm to the Swiss government. Eager to boost tourism in Switzerland, the government commissioned Riggenbach to build a rack railway up Rigi Mountain. Following the construction of a prototype locomotive and test track in a quarry near Bern, the Vitznau-Rigi-Bahn opened on 22 May 1871.

The Riggenbach system is similar in design to the Marsh system. It uses a ladder rack, formed of steel plates or channels connected by round or square rods at regular intervals. The Riggenbach system suffers from the problem that its fixed ladder rack is more complex and expensive to build than the other systems.

Following the success of the Vitznau-Rigi-Bahn, Riggenbach established the *Maschinenfabrik der Internationalen Gesellschaft für Bergbahnen* (IGB) - a company that produced rack locomotives to his design.

Strub

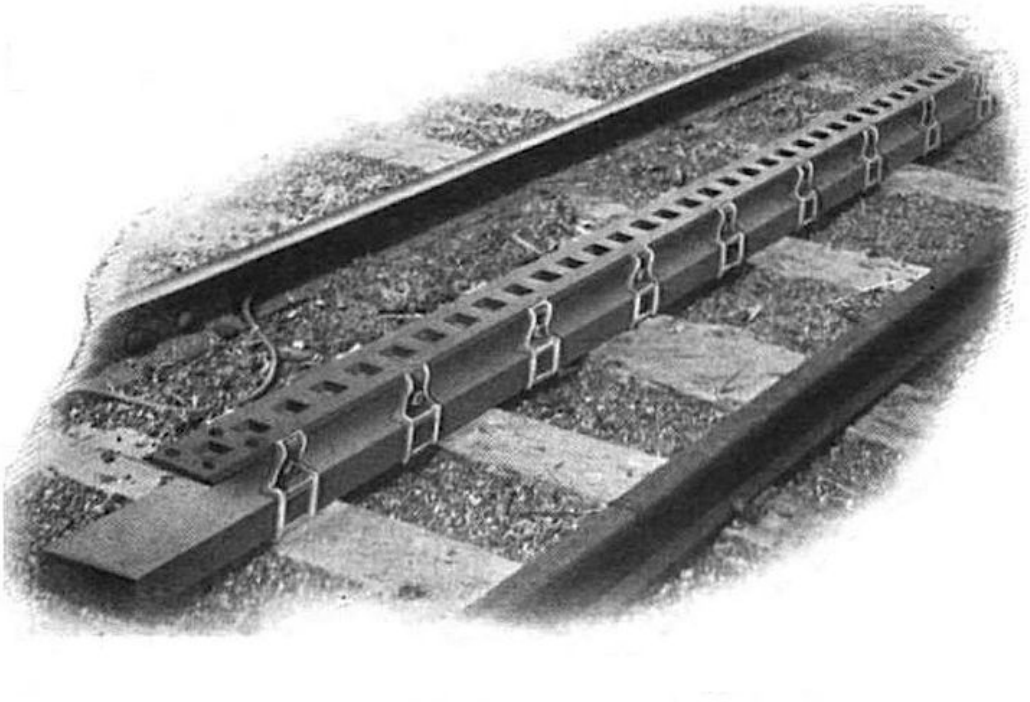


The Strub rack system

The Strub rack system was invented by Emil Strub in 1896. It uses a rolled flat-bottom rail with rack teeth machined into the head approximately 100 mm apart. Safety jaws fitted to the locomotive engage with the underside of the head to prevent derailments and serve as a brake. Strub's US Patent, granted in 1898, also includes details of how the rack rail is integrated with the mechanism of a turnout.

The best-known use of the Strub system is on the Jungfraubahn in Switzerland. It is the simplest rack system to maintain and has become increasingly popular.

Morgan



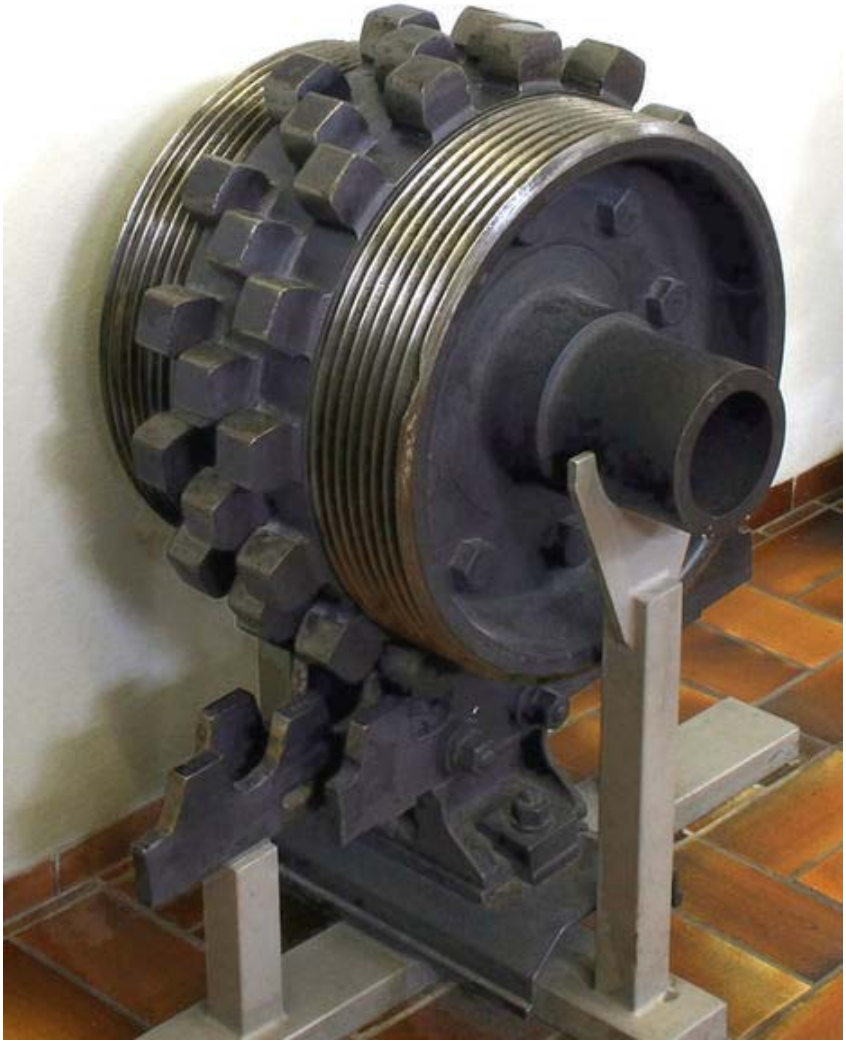
The non-powered variant of the Morgan rack, from the 1919 Goodman catalog.

In 1900, E. C. Morgan of Chicago received a patent on a rack railway system that was mechanically similar to the Riggenbach rack, but where the rack was also used as a third rail to power the electric locomotive. Morgan went on to develop heavier locomotives and with J. H. Morgan, turnouts for this system. In 1904, he patented a simplified but compatible rack, where the teeth on the engine pinions engaged square holes punched in a bar-shaped center rail. J. H. Morgan patented several alternative approaches to building turnouts for use with this new rail. Curiously, Morgan recommended an off-center rack in order to allow clear passage for pedestrians and animals walking along the tracks. Some photos of early Morgan installations show this. A simplified rack mounting system could be used when the Morgan rack was not used for third-rail power and the Morgan rack

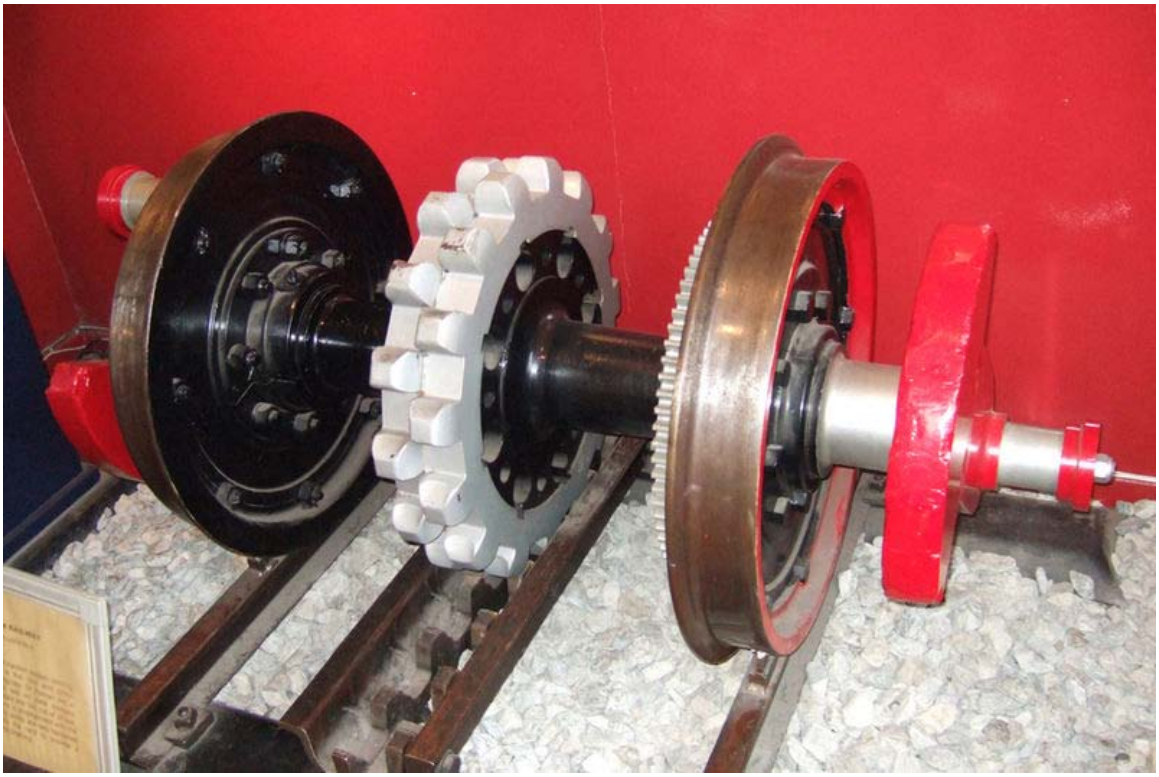
offered interesting possibilities for street railways. The Morgan rack was good for grades of up to 16 percent.

The Goodman Equipment Company began marketing the Morgan system to mining companies, and it saw widespread use in many mines, particularly where steep grades were encountered underground. By 1907, Goodman had offices in Cardiff, Wales to serve the British market. Between 1903 and 1909, the McKell Coal and Coke company in Raleigh County, West Virginia, installed 35,000 feet (10,700 m) of Morgan rack/third-rail track in its mines. The Morgan system saw limited use on one common carrier railroad in the United States, the Chicago Tunnel Company a narrow gauge freight carrier that had one steep grade in the line up to their surface disposal station on the Chicago lakefront.

Abt



Abt rack system



Abt rack system

The Abt system was devised by Roman Abt, a Swiss locomotive engineer. Abt worked for Riggenbach at his works in Olten and later at his IGB rack locomotive company. In 1885 he founded his own civil engineering company.

During the early 1880s, Abt worked to devise an improved rack system that overcame the limitations of the Riggenbach system. In particular, the Riggenbach rack was expensive to manufacture and maintain and the switches were complex. In 1882 Abt designed a new rack using solid bars with vertical teeth machined into them. Two or three of these bars are mounted centrally between the rails, with the teeth offset. The use of multiple bars with offset teeth ensures that the pinions on the locomotive driving wheels are constantly engaged with the rack. The Abt system is cheaper to build than the Riggenbach because it requires a lower weight of rack over a given length. However the Riggenbach system exhibits greater wear resistance than the Abt.

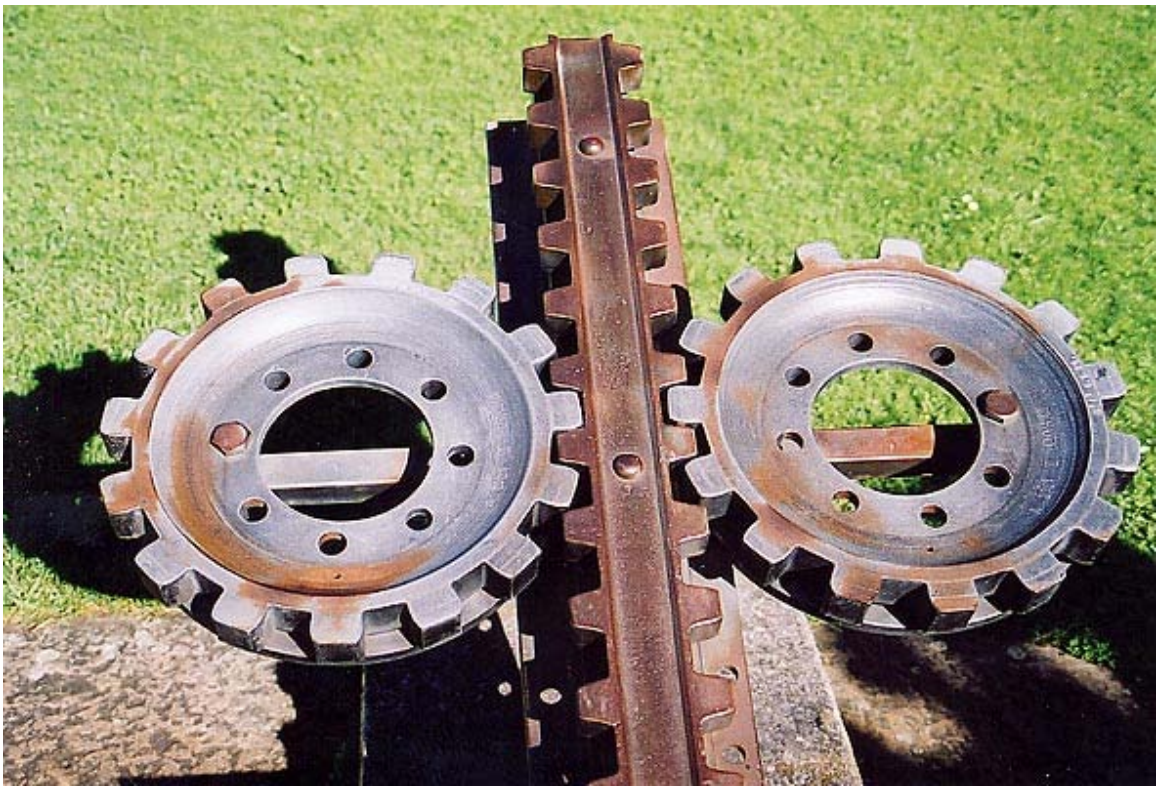
Abt also developed a system for smoothing the transition from friction to rack traction, using a spring-mounted rack section to bring the pinion teeth gradually into engagement.

The first use of the Abt system was on the Harzbahn in Germany which opened in 1885.

The pinion wheels can be mounted on the same axle as the rail wheels (as in the picture at right), or driven separately. The steam locomotives on the Mount Lyell Mining and Railway Company had separate cylinders driving the pinion wheel as do the 'X' Class locomotives on the Nilgiri Mountain Railway.

Locher

Locher rack system



Locher Rack system (seen from above)

The Locher rack system, invented by Eduard Locher, has gear teeth cut in the sides rather than the top of the rail, engaged by two cog wheels on the locomotive. This system allows use on steeper grades than the other systems, whose teeth could jump out of the rack. It is used on the Pilatus Railway.

Locher set out to design a rack system that could be used on gradients as steep as 1 in 2 (50%). The Abt system - the most common rack system in Switzerland at the time - was limited to a maximum gradient of 1 in 4 (25%). Locher showed that on steeper grade, the Abt system was prone to the driving pinion over-riding the rack causing potentially catastrophic derailments, as predicted by Dr. Abt. To overcome this problem and allow a rack line up the steep sides of Mt. Pilatus, Locher developed a rack system where the rack is a flat bar with symmetrical, horizontal teeth. Horizontal pinions engage the centrally-mounted bar, both driving the locomotive and keeping it centered on the track.

This system provides very stable attachment to the track, also protecting the car from toppling over even under the severest cross winds. Such gears are also capable to lead the car, so even flanges on running wheels are optional. The biggest shortcoming of the system seems that the ordinary railway switch is not possible and a transfer table or other complex device must be used where it is needed to branch the track.

Following tests, the Locher system was deployed on the Pilatus Railway which opened in 1889. No other public railway uses the Locher system, although some European coal mines use a similar system on steeply graded underground lines.

Lamella

Joint between Riggenbach and Strub

The Lamella system (also known as the Von Roll system) was developed by the Von Roll company after the rolled steel rails used in the Strub system became unavailable. It is formed from a single blade cut in a similar fashion to the Abt system but typically wider than a single Abt bar. The Lamella rack can be used by locomotives designed for use on the Riggenbach or the Strub systems and some railways use rack from multiple systems. The St. Gallen Gais Appenzell Railway in Switzerland has sections of Riggenbach, Strub and Lamella rack.

Most of the rack railways built from the late 20th century onwards have used the Lamella system.

Rack-and-adhesion systems / Pure rack systems

Rack-and-adhesion systems use the cog drive only on the steepest sections and elsewhere operate as a regular railway. Others, the steeper ones, are rack-only. On the latter type, the locomotives' wheels are generally free-wheeling and despite appearances do not contribute to driving the train. In this case the racks continue also in the horizontal parts, if any.

Fell

The Fell mountain railway system is not strictly speaking a rack railway since there are no cogs with teeth. Rather, this system uses a smooth raised centre rail between the two running rails on steep lines which is gripped on both sides to improve friction. Trains are propelled by wheels or braked by shoes pressed horizontally onto the centre rail, as well as by means of the normal running wheels.

Switches

Railroad switch at von Roll system rack railway (Štrbské Pleso, Slovakia).

Rack railway switches are as varied as rack railway technologies, for optional rack lines such as the Zentralbahn in Switzerland and the West Coast Wilderness Railway in

Tasmania it is convenient to only use switches on sections flat enough for adhesion (for example, on a pass summit). Other systems which rely on the rack for driving (with the conventional rail wheels undriven) such as the Dolderbahn in Zurich, Štrbské Pleso in Slovakia and the Schynige Platte rack railway instead must switch the rack rail. The Dolderbahn switch works by bending all three rails, an operation that is performed every trip as the two trains pass in the middle.

The geometry of the rack system has a large impact on the construction of turnouts. If the rack is elevated above the running rails, there is no need to interrupt the running rails to allow passage of the driving pinions of the engines. Strub explicitly documented this in his U.S. patent. Strub used a complex set of bell-cranks and push-rods linking the throw-rod for the points to the two throw-rods for the moving rack sections. One break in the rack was required to select between the two routes, and a second break was required where the rack rails cross the running rails. These are visible in the photo of the Strub turnout on the Štrbské Pleso railway. Turnouts for the Morgan Rack system were similar, with the rack elevated above the running rails. Most of the Morgan turnout patents included movable rack sections to avoid breaks in the rack, but because all Morgan locomotives had two linked drive pinions, there was no need for a continuous rack. So long as the breaks in the rack were shorter than the distance between the drive pinions on the locomotive, the rack rail could be interrupted wherever there was need to cross over a running rail.

Turnouts are far more complex when the rack is at or below the level of the running rails. Marsh's first rack patent shows such an arrangement, and the original Mount Washington Cog Railroad he built had no turnouts. It was not until 1941 that a turnout was constructed on this line. The new turnouts installed on the Mount Washington line in 200? are essentially transfer tables.

Cog locomotives

Vertical boiler locomotive Arth–Rigi Railway

Rittnerbahn early electric cog locomotive and carriage

Originally almost all cog railways were powered by steam locomotives. The steam locomotive needs to be extensively modified to work effectively in this environment. Unlike a diesel locomotive or electric locomotive, the steam locomotive only works when its powerplant (the boiler, in this case) is fairly level. The locomotive boiler requires water to cover the boiler tubes and firebox sheets at all times, particularly the crown sheet, the metal top of the firebox. If this is not covered with water, the heat of the fire will soften it enough to give way under the boiler pressure, leading to a catastrophic failure.

On rack systems with extreme gradients, the boiler, cab and general superstructure of the locomotive are tilted forward relative to the wheels so that they are more or less

horizontal when on the steeply graded track. These locomotives often cannot function on level track, and so the entire line, including maintenance shops, must be laid on a gradient. This is one of the reasons why rack railways were among the first to be electrified and most of today's rack railways are electrically powered. In some cases, the vertical boiler can be used that is less sensitive for the track gradient.

On a rack-only railroad locomotives always push their passenger cars for safety reasons since the locomotive is fitted with powerful brakes, often including hooks or clamps that grip the rack rail solidly. Some locomotives are fitted with automatic brakes that apply if the speed gets too high, preventing runaways. Often there is no coupler between locomotive and train since gravity will always push the passenger car down against the locomotive. Electrically powered vehicles often have electromagnetic track brakes as well.

The maximum speed of trains operating on a cog railway is very low, generally from 9 to 25 km/h depending on gradient and propulsion method. Because the Skitude has gentler gradients than typical, its speeds are higher than typical.

Chapter 4

Railway Signalling

A gantry of British semaphore signals seen from the cab of a steam locomotive

Railway signalling is a system used to control railway traffic safely, essentially to prevent trains from colliding. Being guided by fixed rails, trains are uniquely susceptible to collision; furthermore, trains cannot stop quickly, and frequently operate at speeds that do not enable them to stop within sighting distance of the driver. In the UK, the Regulation of Railways Act 1889 introduced a series of requirements on matters such as the implementation of interlocked block signalling and other safety measures as a direct result of the Armagh rail disaster in that year.

Most forms of train control involve movement authority being passed from those responsible for each section of a rail network (e.g., a signalman or stationmaster) to the train crew. The set of rules and the physical equipment used to accomplish this determine what is known as the *method of working* (UK), *method of operation* (US) or *safeworking* (Aus.). Not all these methods require the use of physical signals and some systems are specific to single track railways.

The earliest rail cars were first hauled by horses or mules. A mounted flagman on a horse preceded some early trains. Hand and arm signals were used to direct the “train drivers”. Foggy and poor-visibility conditions gave rise to flags and lanterns. Wayside signalling dates back as far as 1832, and used elevated flags or balls that could be seen from afar.

Timetable operation

The simplest form of operation, at least in terms of equipment, is to run the system according to a timetable. A fixed schedule is drawn up with which every train crew must be familiar. Trains may only run on each section of track at their scheduled time, during which they have 'possession' and no other train is permitted to use the same section.

When trains are running in opposite directions on a single-track railroad, meeting points ("meets") are scheduled, at which each train must wait for the other at a passing place. Neither train is permitted to move before the other has arrived. In the US the display of two green flags (green lights at night) is an indication that another train is following the first and the waiting train must wait for the next train to pass. In addition, the train carrying the flags gives eight blasts on the whistle as it approaches. The waiting train must return eight blasts before the flag carrying train may proceed.

The timetable system has several disadvantages. First, there is no positive confirmation that the track ahead is clear, only that it is scheduled to be clear. The system does not allow for engine failures and other such problems, but the timetable is set up so that there should be sufficient time between trains for the crew of a failed or delayed train to walk far enough to set up warning flags, flares, and *detonators* or *torpedoes* (UK and US terminology, respectively) to alert any other train crew.

A second problem is the system's inflexibility. Trains cannot be added, delayed, or rescheduled without advance notice.

A third problem is a corollary of the second: the system is inefficient. To provide flexibility, the timetable must give trains a broad allocation of time to allow for delays, so the line is in the possession of each train for longer than is otherwise necessary.

Nonetheless, this system permits operation on a vast scale, with no requirements for any kind of communication that travels faster than a train. Timetable operation was the normal mode of operation in North America in the early days of the railroad.

Timetable and train order

With the advent of the telegraph in 1851, a more sophisticated system became possible because this provided a means whereby messages could be transmitted ahead of the trains. The telegraph allows the dissemination of any timetable changes, known as *train orders*. These allow the cancellation, rescheduling and addition of train services.

Train crews generally receive their orders at the next station at which they stop, or they are sometimes handed up to a locomotive 'on the run' via a long staff. Train orders allowed dispatchers to set up meets at sidings, force a train to wait in a siding for a priority train to pass, and to maintain at least one block spacing between trains going the same direction.

Timetable and train order operation was commonly used on American railroads until the 1960s, including some quite large operations such as the Wabash Railroad and the Nickel Plate Road. Train order traffic control was used in Canada until the late 1980s on the Algoma Central Railway and some spurs of the Canadian Pacific Railway.

Timetable and train order was not used widely outside North America, and has been phased out in favor of radio dispatch on many light-traffic lines and electronic signals on high-traffic lines. More details of North American operating methods is given below.

Block signalling

British lower-quadrant semaphore stop signal (absolute) with subsidiary arm (permissive) below

Trains cannot collide with each other if they are not permitted to occupy the same section of track at the same time, so railway lines are divided into sections known as *blocks*. In normal circumstances, only one train is permitted in each block at a time. This principle forms the basis of most railway safety systems.

History of block signalling

On double-tracked railway lines, which enabled trains to travel in one direction on each track, it was necessary to space trains far enough apart to ensure that they could not collide. In the very early days of railways, men (originally called 'policemen') were employed to stand at intervals ("blocks") along the line with a stopwatch and use hand signals to inform train drivers that a train had passed more or less than a certain number of minutes previously. This was called "time interval working". If a train had passed very recently, the following train was expected to slow down to allow more space to develop.

The watchmen had no way of knowing whether a train had cleared the line ahead, so if a preceding train stopped for any reason, the crew of a following train would have no way of knowing unless it was clearly visible. As a result, accidents were common in the early days of railways. With the invention of the electrical telegraph, it became possible for staff at a station or signal box to send a message (usually a specific number of rings on a bell) to confirm that a train had passed and that a specific block was clear. This was called the "absolute block system".

Fixed mechanical signals began to replace hand signals from the 1830s. These were originally worked locally, but it later became normal practice to operate all the signals on a particular block with levers grouped together in a signal box. When a train passed into a block, a signalman would protect that block by setting its signal to 'danger'. When an 'all clear' message was received, the signalman would move the signal into the 'clear' position.

The block system came into use gradually during the 1850s and 1860s and became mandatory in the United Kingdom after Parliament passed legislation in 1889 following a number of accidents, most notably the Armagh rail disaster. This required block signalling for all passenger railways, together with interlocking, both of which form the basis of modern signalling practice today. Similar legislation was passed by the United States around the same time.

Not all blocks are controlled using fixed signals. On some single track railways in the UK, particularly those with low usage, it is common to use token systems that rely on the train driver's physical possession of a unique token as authority to occupy the line, normally in addition to fixed signals.

Entering and leaving a manually-controlled block

Before allowing a train to enter a block, a signalman must be certain that it is not already occupied. When a train leaves a block, he must inform the signalman controlling entry to the block. Even if the signalman receives advice that the previous train has left a block, he is usually required to seek permission from the next signal box to admit the next train. When a train arrives at the end of a block section, before the signalman sends the message that the train has arrived, he must be able to see the end-of-train marker on the back of the last vehicle. This ensures that no part of the train has become detached and

remains within the section. The end of train marker might be a white disc by day or a steady or flashing red lamp. If a train has entered the next block before the signalman sees that the disc or lamp is missing, he will ask the next signal box to stop the train and investigate.

Permissive and absolute blocks

Under a permissive block system, trains are permitted to pass signals indicating the line ahead is occupied, but only at such a speed that they can stop safely driving by sight. This allows improved efficiency in some situations and is mostly used in the USA, and in most countries is restricted to freight trains only, and may be restricted depending on the level of visibility.

Permissive block working may also be used in an emergency, either when a driver is unable to contact a signalman after being held at a danger signal for a specific time, although this is only permitted when the signal does not protect any conflicting moves, and also when the signalman is unable to contact the next signal box to make sure the previous train has passed, for example if the telegraph wires are down. In these cases, trains must proceed at very low speed (typically 20 mph or less) so that they are able to stop short of any obstruction. In most cases this will not be allowed during times of poor visibility (e.g. fog or falling snow).

Even when an absolute block system is implemented, multiple trains may enter a block with authorisation. This may be necessary e.g. in order to split or join trains together, or to rescue failed trains. In giving authorisation, the signalman also ensures the driver knows precisely what to expect ahead, and the driver must operate the train in a safe manner taking this information into account. Generally, the signal will remain at danger, and the driver will be given verbal authority, usually accompanied by a yellow flag, to pass a signal at danger, and the presence of the train in front will be explained. At locations where trains regularly enter occupied blocks, such as stations where coupling takes place, a subsidiary signal, sometimes known as a "calling on" signal, will be provided for these movements, otherwise they are accomplished through train orders.

Automatic block

Under automatic block signalling, signals indicate whether or not a train may enter a block based on automatic train detection indicating whether a block is clear. The signals may also be controlled by a signalman, so that they only provide a *proceed* indication if the signalman sets the signal accordingly and the block is clear.

Fixed block

Most blocks are "fixed", i.e. they include the section of track between two fixed points. On timetable, train order, and token-based systems, blocks usually start and end at selected stations. On signalling-based systems, blocks start and end at signals.

The lengths of blocks are designed to allow trains to operate as frequently as necessary. A lightly-used line might have blocks many kilometres long, but a busy commuter line might have blocks a few hundred metres long.

A train is not permitted to enter a block until a signal indicates that the train may proceed, a dispatcher or signalman instructs the driver accordingly, or the driver takes possession of the appropriate token. In most cases, a train cannot enter the block until not only the block itself is clear of trains, but there is also an empty section beyond the end of the block for at least the distance required to stop the train. In signalling-based systems with closely-spaced signals, this overlap could be as far as the signal following the one at the end of the section, effectively enforcing a space between trains of two blocks.

When calculating the size of the blocks, and therefore the spacing between the signals, the following have to be taken into account:

- Line speed (the maximum permitted speed of each train)
- Gradient (to compensate for longer or shorter braking distances)
- The braking characteristics of trains on that line
- Sighting (how far ahead a driver can see a signal)
- Reaction time (of the driver)

Historically, some lines operated so that certain large or high speed trains were signalled under different rules and only given the right of way if two blocks in front of the train were clear.

Moving block

One disadvantage of having fixed blocks is that the faster trains are allowed to run, the longer the stopping distance, and therefore the longer the blocks need to be, thus decreasing the line's capacity.

Under a moving block system, computers calculate a 'safe zone' around each moving train that no other train is allowed to enter. The system depends on knowledge of the precise location and speed and direction of each train, which is determined by a combination of several sensors: active and passive markers along the track and trainborne tachometers and speedometers (GPS systems cannot be used because they do not work in tunnels.) With a moving block, lineside signals are unnecessary, and instructions are passed directly to the trains. This has the advantage of increasing track capacity by allowing trains to run closer together while maintaining the required safety margins.

Moving block is in use on Vancouver's Skytrain, London's Docklands Light Railway, New York City's BMT Canarsie Line, and London's Jubilee Line. It was supposed to be the enabling technology on the modernisation of Britain's West Coast Main Line which would allow trains to run at a higher maximum speed (140 mph), but the technology was deemed not mature enough, considering the large number of junctions on the line, and the

plan was dropped. It forms part of the European Rail Traffic Management System's level-3 specification for future installation in the European Train Control System, which will (at level 3) feature moving blocks that allow trains to follow each other at exact braking distances.

Train detection

Track circuits

One of the most common ways to determine whether a section of line is occupied is by use of a track circuit. The rails at either end of each section are electrically isolated from the next section, and an electrical current is fed to both running rails at one end. A relay at the other end is connected to both rails. When the section is unoccupied, the relay coil completes an electrical circuit, and is energized. However, when a train enters the section, it short-circuits the current in the rails, and the relay is de-energized.

This method does not explicitly need to check that the entire train has left the section. If part of the train is left in the section, that part will continue to be detected by the track circuit.

This type of circuit is used to detect trains, both for the purpose of setting the signal indication and for providing various interlocking functions — for example, not permitting points to be moved when a train is standing over them. Electrical circuits are also used to *prove* that points are in the appropriate position before a signal over them may be cleared. Modern UK trains, and staff working in track circuit block areas, carry operating clips so that, in the event of a derailment fouling an adjacent track, the track circuit can be short-circuited. This places signals on that track to 'danger' and can be used to prevent a collision before the crew is able to contact a signalman.

Axle counters

An alternative method of determining the occupied status of a block is using devices located at its beginning and end that count the number of axles entering and leaving. If the same number leave the block as enter it, the block is assumed to be clear. Although axle counters can provide similar functionality to track circuits, they also exhibit a few other characteristics. In a damp environment an axle counted section can be far longer than a track circuited one. The low ballast resistance of very long track circuits reduces their sensitivity. Track circuits can automatically detect some types of track defect such as a broken rail. In the event of power restoration after a power failure, an axle counted section is left in an undetermined state until a train has passed through the affected section. When a block section has been left in an undetermined state, it may be worked under pilot working. The first train to pass through the section would typically do so at a speed no greater than 20 mph or walking pace in areas of high transition, reverse curvature and may have someone who has a good local knowledge of the area acting as the pilotman. A track circuited section will detect the presence of a train in section immediately.

Fixed signals

On most railways, physical signals are erected at the lineside to indicate to drivers whether the line ahead is occupied and to ensure that sufficient space exists between trains to allow them to stop.

Mechanical signals

Older forms of signal displayed their different aspects by their physical position. The earliest types comprised a board that was either turned face-on and fully visible to the driver, or rotated so as to be practically invisible. While this type of signal is still in use in some countries (e.g. France and Germany), by far the most common form of mechanical signal worldwide is the *semaphore signal*. This comprises a pivoted arm or blade that can be inclined at different angles. A horizontal arm is the most restrictive indication (for 'danger' or 'caution', depending on the type of signal).

To enable trains to run at night, one or more lights are usually provided at each signal. Typically this comprises a permanently-lit oil lamp with movable coloured spectacles in front that alter the colour of the light. The driver therefore had to learn one set of indications for day time viewing and another for night time viewing.

Whilst it is normal to associate the presentation of a green light with a safe condition, this was not historically the case. In the very early days of railway signalling, the first coloured lights (associated with the turned signals above) presented a white light for 'clear' and a red light for 'danger'. Green was originally used to indicate 'caution' but fell out of use when the time interval system was discontinued. A green light subsequently replaced white for 'clear', to address concerns that a broken red lens could be taken by a driver as a false 'clear' indication. It was not until scientists at Corning Glassworks perfected a shade of yellow without any tinges of green or red that yellow became the accepted colour for 'caution'.

Mechanical signals are usually remotely operated by wire from a lever in a signal box, but electrical or hydraulic operation is normally used for signals that are located too distant for manual operation.

Colour light signals

Vertical colour light signal on the Enshū Railway Line in Japan

On most modern railways, colour light signals have largely replaced mechanical ones. Colour light signals have the advantage of displaying the same aspects by night as by day, and require less maintenance than mechanical signals.

Although signals vary widely between countries, and even between railways within a given country, a typical system of aspects would be:

- Green: Proceed at line speed. Expect to find next signal displaying green or yellow.
- Yellow: Prepare to find next signal displaying red.

- Red: Stop.

On some railways, colour light signals display the same set of aspects as shown by the lights on mechanical signals during darkness.

Route signalling and speed signalling

Signalling of British origin generally conforms to the principle of *route signalling*. Most railway systems around the world, however, use what is known as *speed signalling*.

Under **route signalling**, a driver is informed which route the train will take beyond each signal (unless only one route is possible). This is achieved by a *route indicator* attached to the signal. The driver uses his route knowledge, reinforced by speed restriction signs fixed at the lineside, to drive the train at the correct speed for the route to be taken. This method has the disadvantage that the driver may be unfamiliar with a route onto which he has been diverted due to some emergency condition. Several accidents have been caused by this alone. For this reason, in the UK drivers are only allowed to drive on routes that they have been trained on and must regularly 'practice' on lesser used diversionary routes to keep their route knowledge up to date.

Under **speed signalling**, the driver is not informed which route the train will take, but the signal aspect informs him at what speed he may proceed. Speed signalling requires a far greater range of signal aspects than route signalling, but less dependence is placed on drivers' route knowledge.

Approach release

When the train is routed towards a diverging route that must be taken at a speed significantly less than the mainline speed, the driver must be given adequate prior warning.

Under 'route signalling', the aspects necessary to control speed do not exist, so a system known as *approach release* is employed. This involves holding the junction signal at a restrictive aspect (typically 'stop') in order that the signals on the approach show the correct sequence of caution aspects. The driver will brake in accordance with the caution aspect, without necessarily being aware that the diverging route has in fact been set. As the train approaches the junction signal, its aspect may clear to whatever aspect the current track occupancy ahead will permit. Where the turnout speed is the same, or nearly the same, as the mainline speed, approach release is unnecessary.

With speed signalling, the signals approaching the divergence will display aspects appropriate to control the trains speed, so no 'approach release' is required.

Safety systems

The consequence of a driver/engineer failing to respond to a signal's indication can be disastrous. As a result, various auxiliary safety systems have been devised. Any such system will necessitate the installation of trainborne equipment to some degree. Some systems only intervene in the event of a signal being passed at danger. Others include audible and/or visual indications inside the driver's cab to supplement the lineside signals. Automatic brake application occurs if the driver should fail to acknowledge a warning. Some systems act intermittently (at each signal), but the most sophisticated systems provide continuous supervision.

In-cab safety systems are of great benefit during fog, when poor visibility would otherwise require that restrictive measures be put in place.

Cab signalling

Example of cab signal

Cab signalling is a system that communicates track status information to the train cab (driving position), where the engine driver can see the information. The simplest systems

display the trackside signal aspect, while more sophisticated systems also display allowable speed and dynamic information about the track ahead. In modern systems, a train protection system is usually overlaid on top of the cab signalling system to warn the driver of dangerous conditions, and to automatically apply the brakes and bring the train to a stop if the driver ignores the dangerous condition. Cab signalling systems range from simple coded track circuits, to transponders that communicate with the cab, and communication-based train control systems.

Interlocking

In the early days of the railways, signalmen were responsible for ensuring any points (US: switches) were set correctly before allowing a train to proceed. Mistakes were made which led to accidents, sometimes with fatalities. The concept of the interlocking of points, signals and other appliances was introduced to improve safety. This prevents a signalman from operating appliances in an unsafe sequence, such as setting a signal to 'clear' while one or more sets of points in the route ahead of the signal are improperly set.

Early interlocking systems used mechanical devices both to operate the signalling appliances and to ensure their safe operation. Beginning around the 1930s, electrical relay interlockings were used. Since the late 1980s, new interlocking systems have tended to be of the electronic variety.

Operating rules

Operating rules, policies and procedures are used by railroads to enhance safety. Specific operating rules may differ from country to country and even from railroad to railroad within the same country.

Australian operating rules

In Australia, operating rules are called Safeworking.

North American operating rules

In North America and especially the US, operating rules are called *method of operation*. There are five main sets of operating rules in North America:

- Canadian Rail Operating Rules (CROR), used by most Canadian railroads
- General Code of Operating Rules (GCOR), used by many Class I railroads, Class II railroads, and many Short-line railroads
- Northeast Operating Rules Advisory Committee (NORAC), used by many railroads in the Northeast US
- Class I Norfolk Southern uses a unique set of operating rules.
- Class I CSX Transportation uses a unique set of operating rules.

UK operating rules

In the UK, operating rules are called *method of working*. It is commonly known as the "Rule-book" by railway employees. It is controlled by the Rail Safety and Standards Board (RSSB), which is independent from Network Rail or any other Train/Freight Operating Company. Most heritage railways operate to a simplified variant of a British Railways rule book.

Italian operating rules

In Italy, railway signalling is described in a particular instruction called *Regolamento Segnali* (*Signal Regulation*).

Chapter 5

Railroad Tie

While wooden ties dominate North American railways, concrete is widely used in other parts of the world.

A **railway sleeper**, **railroad tie** (US usage), or **railway tie** (Canadian usage) is a rectangular object used as a base for railroad tracks. Ties are members generally laid

transverse to the rails, on which the rails are supported and fixed, to transfer the loads from rails to the ballast and subgrade, and to hold the rails to the correct gauge.

Traditionally, ties have been made of wood, but concrete is now widely used. Steel ties and plastic composite ties are currently used as well, although far less than wood or concrete ties. As of January 2008, the approximate market share, in North America, for traditional and wood ties was 91.5%, whereas the approximate combined market share for (all) concrete, steel, azobe (exotic hardwood) and plastic composite ties was 8.5%.

Ties are normally laid on top of track ballast, which supports and holds them in place, and provides drainage and flexibility. Heavy crushed stone is the normal material for the ballast, but on lines with lower speeds and weight, sand, gravel, and even ash from the fires of coal-fired steam locomotives have been used.

Approximately 3000 ties are used per mile of railroad track. Ties/sleepers are set much closer together in the USA, where rails are traditionally fastened to the ties by a railroad spike rather than the substantial iron/steel chairs used in Europe.

Types

Stone block

The type of sleeper used on the predecessors of the first true railway (Liverpool and Manchester Railway) consisted of a pair of stone blocks laid into the ground, with the chairs holding the rails fixed to those blocks. One advantage of this method of construction was that it allowed horses to tread the middle path without the risk of tripping. In railway use with ever heavier locomotives, it was found that it was hard to maintain the correct gauge. The stone blocks were in any case unsuitable on soft ground, where something like timber sleepers had to be used. Two centuries later, stone sleepers would reappear in the form of slab track.

Wooden

A variant fastening of rails to wooden ties

Timber ties are usually of a variety of hardwoods, oak being a popular material. Some lines use softwoods, sometimes due to material necessity; while they have the advantage of accepting treatment more readily, they are more susceptible to wear. They are often heavily creosoted. Creosote treating can reduce insect infestation and rot. For more information on creosote and the environment the Creosote Council maintains a comprehensive. Less often, ties are treated with other preservatives. New boron based wood preserving technology is being employed by major US railroads in a dual treatment process in order to extend the life of wood ties in wet areas. Some timbers (such as sal) are durable enough that they can be used untreated.

Problems with wood ties include rot, splitting, insect infestation, plate-cutting (abrasive damage to the tie caused by lateral motion of the tie plate) and spike-pull (where the spike is gradually worked out and loosened from the tie). For more information on wood ties the Railway.

Concrete

Interest in concrete railroad ties was revived due to material shortages after World War II.

Concrete ties have become more common mainly due to greater economy and better support of the rails under high speed and heavy traffic than wooden ties. In early railway history, wood was the only material used for making ties in Europe. Even in those days, occasional shortages and increasing cost of wood posed problems. This induced engineers to seek alternatives to wooden ties. As concrete technology developed in the 19th century, concrete established its place as a versatile building material and could be adapted to meet the requirements of railway industry.

In 1877, M. Monnier, a French gardener, suggested that concrete could be used for making ties for railway track. Monnier designed a tie and obtained a patent for it, but it was not successful. Designs were further developed and the railways of Austria and Italy used the first concrete ties around the turn of the 20th century. This was closely followed by other European railways.

Major progress could not be achieved until World War II, when the timbers used for ties were extremely scarce due to material shortages. Due to research carried out on French and other European railways, the modern concrete tie was developed. Heavier rail sections and long welded rails were also being produced, requiring higher-quality ties.

These conditions spurred the development of concrete ties in France, Germany and Britain, where the technology was perfected.

Steel

Steel Sleepers

In past times steel ties (sleepers) have suffered from poor design and increased traffic loads over their normal long service life. These aged and often obsolete designs limited load and speed capacity but can still, to this day, be found in many locations globally and performing adequately despite decades of service. There are great numbers of steel ties with over 50 years of service and in some cases they can and have been rehabilitated and continue to perform well.

Modern day steel ties, particularly in North America where track loads are greater than in other continents, are not the steel ties of old. Newer steel ties handle heavy loads, have proven performance in signalized track, and handle adverse track conditions. Of high importance to railroad companies is the fact that steel ties are more economical to install in new construction than creosote treated wood ties and concrete ties. Steel ties are 100% recyclable and require up to 60% less ballast than concrete ties and up to 45% less than wood ties.

Steel ties are utilized in nearly all sectors of the worldwide railroad systems including Heavy-Haul, Class 1's, Regional, Shortlines, Mining, Electrified Passenger Lines (OHLE) and all manner of industries.

Notably, steel ties (bearers) have proven themselves over the last few decades to be advantageous in turnouts (switches) and provide the solution to the ever growing problem of long timber ties for such use.

The steel ties' cost benefits together with the ability to hold rail gauge, lower long-term maintenance costs, increase the life of other track components, reduce derailments and meet ever growing and stricter environment standards provide railroad companies with savings and capital to redirect to other areas of maintenance-of-way and business projects.

Plastic/Rubber Composite

In more recent times, a number of companies are selling composite railroad ties manufactured from recycled plastic resins, and recycled rubber. These ties are said to outlast the classic wooden tie, and are impervious to rot and insect attack, and can be modified to provide additional lateral stability while otherwise exhibiting properties similar to their wooden counterparts in terms of damping impact loads and sound absorption.

Aside from the environmental benefits of using recycled material, plastic ties usually replace hardwood ties soaked in creosote, the latter being a toxic chemical, and are themselves recyclable. Plastic/Rubber composite ties are used in other rail applications such as underground mining operations.

Non conventional sleeper forms

Y shaped sleepers

Y sleeper track next to conventional track

An unusual form of sleeper is the Y shaped sleeper. First developed in 1983, Y steel sleepers have advantages and disadvantages compared to conventional steel sleepers. Compared to conventional sleepers the volume of ballast required is reduced due to the load spreading characteristics of the Y-sleeper. Noise levels are high but the resistance to track movement is very good. For curves the three point contact of a Y steel sleeper means that an exact geometric fit cannot be observed with a fixed attachment point.

The cross section of the sleepers is an I-beam.

As of 2006 less than 1000 km of Y-sleeper track had been built of which approximately ninety percent is in Germany.

Twin sleepers

The ZSX Twin sleeper is manufacturer by Leonhard Moll Betonwerke GmbH & Co KG and is a pair of two pre-stressed concrete sleepers longitudinally connected by four steel rods. The design is said to be suitable for regions with sharp curves, track subject to temperature stress such as that operated by trains with eddy brakes, bridges and as transition track between traditional track and slab track or bridges.

Wide sleepers

Concrete monoblock sleepers have also been produced in a wider form (e.g. 57 cm (22 in)) such that there is no ballast between the sleepers; this wide sleeper increase lateral resistance and reduces ballast pressure. The system has been used in Germany where wide sleepers have also been used in conjunction with the GETRAC A3 ballastless track systems.

Bi-block sleepers

Bi-block (or twinblock) sleepers consist of two concrete rail supports joined by steel. Advantages include increase lateral resistance and lower weight than monobloc concrete sleepers, as well as elimination of damage from torsional forces on the sleeper centre due the more flexible steel connections. This sleeper type is in common use in France, and are used on the high-speed TGV lines. Bi-block sleepers are also used in ballastless track systems.

Frame sleepers

Frame sleepers (German: *Rahmenschwelle*) comprise both lateral and longitudinal members in a single monolithic concrete casting. This system is in use in Austria; in the Austrian system the track is fastened at the four corners of the frame, and is also supported midway along the frame. Adjacent frame sleepers are butted close to each other. Advantages of this system over conventional cross tie sleepers are reduced ballast pressure (up to half), increased lateral resistance, and increased support of track. In addition, construction methods used for this type of track are similar to those used for conventional track.

Ladder track

In ladder track the "sleepers" are laid parallel to the rails and are several meters in length. The structure is similar to Brunel's baulk track; these longitudinal sleepers can be used with ballast, or with elastomer supports on a solid non-ballasted support.

Fastening rails to railroad ties

Various methods exist for fixing the rail to the sleeper (railroad tie). Historically spikes gave way to cast iron chairs fixed to the sleeper, more recently springs (such as Pandrol clips) are used to fix the rail to the sleeper chair.

Other uses

Wooden sleepers recycled as sculptures at Northfield station

In recent years, wooden railroad ties have also become popular for gardening and landscaping, both in creating retaining walls and raised-bed gardens, and sometimes for building steps as well. Traditionally, the ties sold for this purpose are decommissioned ties taken from rail lines when replaced with new ties, and their lifespan is often limited due to rot. Some entrepreneurs sell new ties. However, due to the presence of wood preservatives such as coal tar, creosote or salts of heavy metals, railroad ties introduce an extra element of soil pollution into gardens and are avoided by many property owners. In the UK, new oak beams of the same size as standard railroad ties, but not treated with dangerous chemicals, are now available specifically for garden construction. They are about twice the price of the recycled product. In some places, railroad ties have been used in the construction of homes, particularly among those with lower incomes, especially

those residing near railroad tracks, including railroad employees. They are also used as cribbing for docks and boathouses.

The Spanish artist Agustín Ibarrola has used recycled ties from RENFE in several projects.

In Germany, use of wooden railroad ties as building material (namely in gardens, houses and in all places where regular contact to human skin would be likely, in all areas frequented by children and in all areas associated with the production or handling of food in any way) has been prohibited by law since 1991 because they pose a significant risk to health and environment. From 1991 to 2002, this was regulated by the *Teerölverordnung* (Carbolineum By-law), and since 2002 has been regulated by the *Chemikalien-Verbotsverordnung* (Chemicals Prohibition By-law), §1 and Annex, Parts 10 and 17.

Ballastless track

Slab track, System "Rheda 2000", prior to concrete pouring.

Slab track, System "FF Bögl" on Nuremberg-Munich high-speed rail line

slab track at St Pancras station

First such tracks were mountain railways (like Pilatus railway, built in 1889) with rails attached directly to the mountain rock. From the late 1960s onwards, German, British, Swiss and Japanese railroads experimented with alternatives to the traditional railway tie in search of solutions with higher accuracy and longevity, and lowered maintenance costs.

This gave rise to the ballastless railway track, especially in tunnels, high-speed rail lines and on lines with high train frequency, which have high stress imposed on trackage. Paved concrete track has the rail fastened directly to a concrete slab, about half a meter thick, without ties. A similar but less expensive alternative is to accurately position concrete ties and then pour a concrete slab between and around them; this method is called "cast-in precast sleeper track".

These systems offer the advantage of superior stability and almost complete absence of deformation. Ballastless track systems incur significantly lower maintenance costs compared to ballasted track. Due to the absence of any ballast, damage by flying ballast is eliminated, something that occurs at speeds in excess of 250 km/h (150 mph). It is also useful for existing railroad tunnels; as slab track is of shallower construction than ballasted track, it may provide the extra overhead clearances necessary for converting a line to overhead electrification, or for the passage of larger trains.

Building a slab track is more expensive than building traditional ballasted track, which has slowed its introduction outside of high-speed rail lines. These layouts are not easy to modify after they are installed, and the curing time of the concrete makes it difficult to convert an existing, busy railway line to a ballastless setup.

Slab track can also be significantly louder and cause more vibration than traditional ballasted track. While this is in some part attributable to slab track's decreased sound absorption qualities, a more significant factor is that slab track typically uses softer rail fasteners to provide vertical compliance similar to ballasted track; these can lead to more noise, as they permit the rail to vibrate over a greater length.

Where it is critical to reduce noise and vibration, the concrete slab can be supported upon soft resilient bearings. This configuration, called "floating slab track", is expensive and requires more depth or height, but can reduce noise and vibration by around 80%. Alternatively, the rail can be supported along its length by an elastic material; when combined with a smaller rail section, this can provide a significant noise reduction over traditional ballasted track.

Chapter 6

Track (Rail Transport)

Twin track of train rails in a wooded area

The **track** on a railway (non-US) or railroad (US), also known as the **permanent way**, is the structure consisting of the rails, fasteners, sleepers and ballast (or slab track), plus the underlying subgrade. For clarity it is often referred to as **railway track** (British English and UIC terminology) or **railroad track** (predominantly in North America).

The term *permanent way* also refers to the track in addition to lineside structures such as fences etc.

Track structure

Traditional track structure

Railroad tracks on traditional wooden sleepers

Notwithstanding modern technical developments, the overwhelmingly dominant track form worldwide consists of flat-bottom steel rails supported on timber or pre-stressed concrete sleepers (referred to as railroad ties in the US), which are themselves laid on crushed stone ballast.

Most railroads with heavy traffic use continuously welded rails supported by sleepers (ties) attached via baseplates (tieplates) which spread the load. A plastic or rubber pad is usually placed between the rail and the tieplate where concrete sleepers (ties) are used. The rail is usually held down to the sleeper (tie) with resilient fastenings, although cut spikes are widely used in North American practice.

Timber sleepers (ties) are of many available timbers, and are often treated with creosote, copper-chrome-arsenic, or other wood preservative. Pre-stressed concrete sleepers (ties)

are often used where timber is scarce and where tonnage and/or speeds are high. Steel is used in some applications.

On this Japanese high speed line mats have been added to stabilize the ballast

The track ballast is customarily crushed stone, and the purpose of this is to support the ties and allow some adjustment of their position, while allowing free drainage.

Ballastless track

China high speed rail ballastless tracks

A disadvantage of traditional track structures is the heavy demand for maintenance, particularly surfacing (tamping) and lining to restore the desired track geometry and smoothness of vehicle running. Weakness of the subgrade and drainage deficiencies also lead to heavy maintenance costs. This can be overcome by using ballastless track. In its simplest form this consists of a continuous slab of concrete (like a highway structure) with the rails supported directly on its upper surface (using a resilient pad).

There are a number of proprietary systems, and variations include continuous in situ placing of a reinforced concrete slab, or alternatively the use of pre-cast pre-stressed concrete units laid on a base layer. Many permutations of design have been put forward.

However ballastless track is very expensive in first cost, and in the case of existing railroads requires closure of the route for a somewhat long period. Its whole life cost can be lower because of the great reduction in maintenance requirement. Ballastless track is usually considered for new very high speed or very high loading routes, in short extensions that require additional strength (i.e. rail station), or for localised replacement in the case of exceptional maintenance difficulties.

Ladder track

Ladder track utilizes longitudinal sleepers with gauge restraining cross members, it can be considered a development of Baulk road. Both ballasted and ballastless types exist.

Obsolescent track types

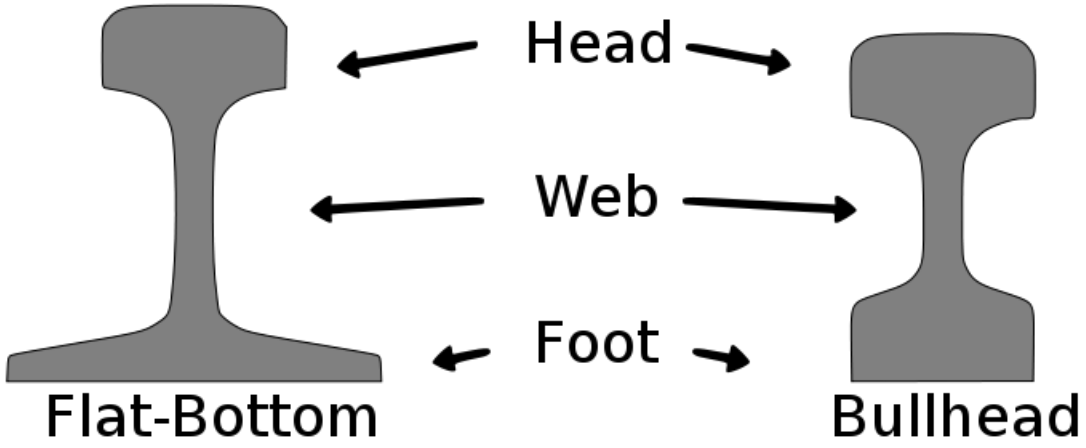
For much of the 20th century, rail track used softwood timber ties and jointed rails, and considerable extents of this track type remains on secondary and tertiary routes. The rails were typically of flat bottom section fastened to the ties with dogspikes through a flat tieplate in North America and Australia, and typically of bullhead section carried in cast iron chairs in British and Irish practice.

Jointed rails were used, at first because the technology did not offer any alternative. However the intrinsic weakness in resisting vertical loading results in the ballast support becoming depressed and a heavy maintenance workload is imposed to prevent unacceptable geometrical defects at the joints. The joints also required to be lubricated, and wear at the fishplate (joint bar) mating surfaces needed to be rectified by shimming. For this reason jointed track is not financially appropriate for heavily operated railroads.

Historical development

The technology of rail tracks developed over a long period, starting with primitive timber rails in mines in the 17th century.

Rail



Cross-sections of flat-bottomed rail, which can rest directly on the sleepers, and bullhead rail which sits in a chair (not shown)

Hot rolled steel in the profile (cross section) of an asymmetrical I-beam is usually used as the surface on which railway wheels run. Unlike some other uses of iron and steel, railway rails are subject to very high stresses and have to be made of very high quality

steel alloy. It took many decades to improve the quality of the materials, including the change from iron to steel. The heavier the rails and the rest of the trackwork, the heavier and faster the trains the track can carry.

Profiles of rail include:

- Bullhead rail
- Grooved rail
- Vignoles rail *(flat-bottomed rail)*
- Flanged T rail
- Bridge rail (inverted U)
- Barlow rail (inverted V)

North American railroads until the mid- to late-20th century used rails 39 ft (11.89 m) long so they could be carried to and from a worksite in gondola cars (open wagons), often 40 ft (12 m) long; as gondola sizes increased, so did rail lengths.

The world's longest rail sections are 120m long and are made by various companies.

Rail classification (weight)

Weight mark on a jointed segment of 155 lb/yd (76.9 kg/m) "Pennsylvania Special" rail, the heaviest grade of rail to be mass-produced

Rail is graded by weight over a standard length. Heavier rail can support greater axle loads and higher train speeds without sustaining damage than lighter rail, but at a greater cost. In North America and the UK, rail is graded in pounds per yard (usually shown as *pound* or *lb*), so *130-pound rail* would weigh 130 lb/yd (64.5 kg/m). The usual range is 115 to 141 lb/yd (57.0 to 69.9 kg/m). In Europe, rail is graded in kg/m and the usual range is 40 to 60 kg/m (80.6 to 121.0 lb/yd). The heaviest rail mass-produced was 155 pounds per yard (76.9 kg/m) and was rolled for the Pennsylvania Railroad. The UK is in the process of transition from the imperial to metric rating of rail.

Joining rails

Rails are produced in fixed lengths and need to be joined end-to-end to make a continuous surface on which trains may run. The traditional method of joining the rails is to bolt them together using metal fishplates, producing *jointed track*. For more modern usage, particularly where higher speeds are required, the lengths of rail may be welded together to form **continuous welded rail** (CWR).

Jointed track

Fishplate between two sections of jointed bullhead rail

Bonded main line 6-bolt rail joint on a segment of 155 lb/yd (76.9 kg/m) rail. Note how bolts are oppositely oriented to prevent complete separation of the joint in the event of being struck by a wheel during a derailment.

Jointed track is made using lengths of rail, usually around 20 m (66 ft) long (in the UK) and 39 or 78 feet (11.9 or 23.8 m) long (in North America), bolted together using perforated steel plates known as *fishplates* (UK) or *joint bars* (North America).

Fishplates are usually 600 mm (1.97 ft) long, used in pairs either side of the rail ends and bolted together (usually four, but sometimes six bolts per joint). The bolts may be oppositely-oriented so that in the event of a derailment and a wheel flange striking the joint, only some of the bolts will be sheared, reducing the likelihood of the rails misaligning with each other and exacerbating the seriousness of the derailment. (This technique is not applied universally, British practice being to have all the bolt heads on the same side of the rail.) Small gaps known as expansion joints are deliberately left between the rail ends to allow for expansion of the rails in hot weather. The holes through which the fishplate bolts pass are oval to allow for movement with expansion.

British practice was to have the rail joints on both rails adjacent to each other, while North American practice is to stagger them.

Because of the small gaps left between the rails, when trains pass over jointed tracks they make a "clickety-clack" sound. Unless it is well-maintained, jointed track does not have the ride quality of welded rail and is less desirable for high speed trains. However, jointed

track is still used in many countries on lower speed lines and sidings, and is used extensively in poorer countries due to the lower construction cost and the simpler equipment required for its installation and maintenance.

A major problem of jointed track is cracking around the bolt holes, which can lead to the rail head (the running surface) breaking. This was the cause of the Hither Green rail crash which caused British Railways to begin converting much of its track to Continuous Welded Rail.

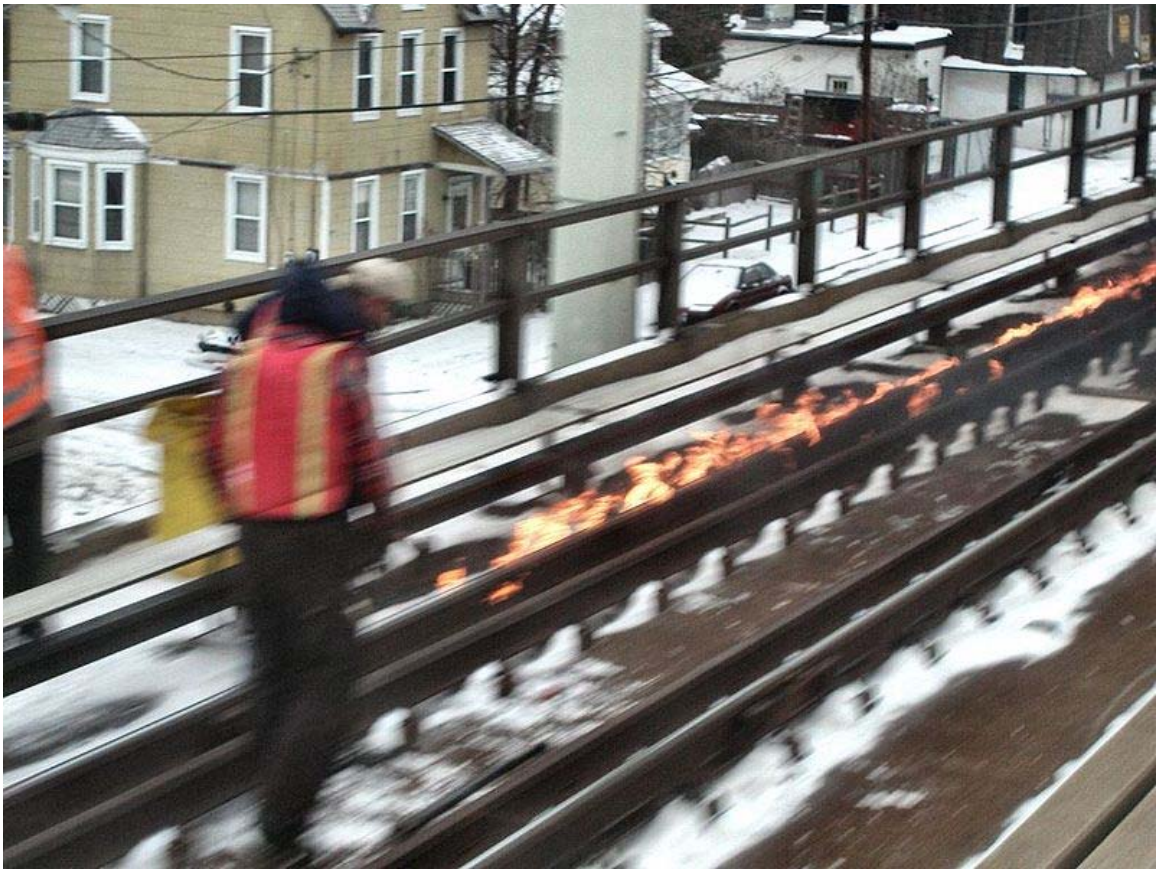
Insulated joints

Where track circuits exist for signalling purposes, insulated block joints are required. These compound the weaknesses of ordinary joints. Specially-made glued joints, where all the gaps are filled with epoxy resin, increase the strength again.

As an alternative to the insulated joint, audio frequency track circuits can be employed using a tuned loop formed in approximately 20 m of the rail as part of the blocking circuit. Another alternative is the axle counter, which can reduce the number of track circuits and thus the number of insulated rail joints required.

Continuous welded rail

Welded rail joint



A pull-apart on the Long Island Rail Road Babylon Branch being repaired by using flaming rope to expand the rail back to a point where it can be joined together

An expansion joint on CWR at Montague Gardens, Cape Town, South Africa

Most modern railways use **continuous welded rail** (CWR), sometimes referred to as **ribbon rails**. In this form of track, the rails are welded together by utilising flash butt welding to form one continuous rail that may be several kilometres long, or thermite welding to repair or splice together existing CWR segments. Because there are few joints, this form of track is very strong, gives a smooth ride, and needs less maintenance; trains can travel on it at higher speeds and with less friction. Welded rails are more expensive to lay than jointed tracks, but have much lower maintenance costs. The first welded track was used in Germany in 1924 and the US in 1930 and has become common on main lines since the 1950s.

Flash butt welding is the preferred process which involves an automated track-laying machine running a strong electrical current through the touching ends of two unjoined pieces of rail. The ends become white hot due to electrical resistance and are then pressed together forming a strong weld. Thermite welding is a manual process requiring a reaction crucible and form to contain the molten iron. Thermite-bonded joints are also seen as less reliable and more prone to fracture or break.

If not restrained, rails would lengthen in hot weather and shrink in cold weather. To provide this restraint, the rail is prevented from moving in relation to the sleeper by use of clips or anchors. Anchors are more common for wooden sleepers, whereas most concrete or steel sleepers are fastened to the rail by special clips which resist longitudinal movement of the rail. There is no theoretical limit to how long a welded rail can be.

However, if longitudinal and lateral restraint are insufficient, the track could become distorted in hot weather and cause a derailment. Distortion due to heat expansion is known in North America as sun kink, and elsewhere as buckling. In North America a rail broken due to cold-related contraction is known as a *pull-apart*. Attention needs to be paid to compacting the ballast effectively, including under, between, and at the ends of the sleepers, to prevent the sleepers from moving. In extreme hot weather special inspections are required to monitor sections of track known to be problematic.

After new segments of rail are laid, or defective rails replaced (welded-in), the rails are artificially stressed. The stressing process involves either heating the rails causing them to expand, or stretching the rails with hydraulic equipment. They are then fastened (clipped) to the sleepers in their expanded form. This process ensures that the rail will not expand much further in subsequent hot weather. In cold weather the rails try to contract, but because they are firmly fastened, cannot do so. In effect, stressed rails are a bit like a piece of stretched elastic firmly fastened down.

CWR rail is laid (including fastening) at a temperature roughly midway between the extremes experienced at that location (this is known as the "rail neutral temperature"). This installation procedure, along with normal track structure strength, is intended to prevent tracks from buckling in summer heat or pulling apart in winter cold. In North America, because broken rails are typically detected by the signaling system; they are seen as less of a problem than heat kinks which are not detected.

Joints are used in continuous welded rail when necessary, usually for signal circuit gaps. Instead of a joint that passes straight across the rail, the two rail ends are sometimes cut at an angle to give a smoother transition. In extreme cases, such as at the end of long bridges, a breather switch (referred to in North America and Britain as an *expansion joint*) gives a smooth path for the wheel while allowing the end of one rail to expand in relation to the next rail.

Rail support (sleeper/tie)

A railroad tie (also called a cross-tie in North American usage, or a railway sleeper outside North America) is a rectangular object on which the rails are supported and fixed. The tie has two main roles: to transfer the loads from the rails to the track ballast and the ground underneath, and to hold the rails to the correct width apart (to maintain the rail gauge). They are generally laid transverse (perpendicular) to the rails.

Fixing rails to railroad ties

Various methods exist for fixing the rail to the sleeper (railroad tie). Historically spikes gave way to cast iron chairs fixed to the sleeper, more recently springs (such as Pandrol clips) are used to fix the rail to the sleeper chair.

Portable track

Sometimes rail tracks are designed to be portable and moved from one place to another as required.

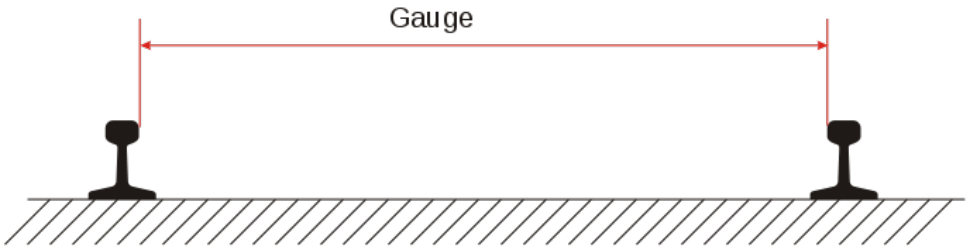
On the Panama Canal, tracks were so lifted around as is seen in moving pictures taken of the excavation works. These tracks were standard gauge, and the rolling stock full size.

Cane railways often had permanent tracks for the main lines, with portable tracks serving the canefields themselves. These tracks were narrow gauge (for example, 2 ft (610 mm)) and the portable track came in straights, curves and turnouts rather like on a model railway.

Decauville was a source of many portable light rail tracks, also used for military purposes.

The **permanent way** is so called because **temporary way** tracks were often used in the construction of that permanent way.

Gauge



Measuring rail gauge

During the early days of rail, there was considerable variation in the gauge used by different systems. Today, 60% of the world's railways use a gauge of 1,435 mm (4 ft 8 ½ in), known as standard or international gauge. Gauges wider than standard gauge are called broad gauge; narrower, narrow gauge. Some stretches of track are dual gauge, with three (or sometimes four) parallel rails in place of the usual two, to allow trains of two different gauges to share the same track.

Gauge can safely vary over a range. For example, U.S. federal safety standards allow standard gauge to vary from 4 ft 8 in (1,422 mm) to 4 ft 9 ½ in (1,460 mm) for operation up to 60 mph (96.6 km/h).

Track maintenance

Maintenance of way equipment in Italy

Track needs regular maintenance to remain in good order, especially when high-speed trains are involved. Inadequate maintenance may lead to a "slow order" (North American terminology, a "slack" or speed restriction in the United Kingdom) being imposed to avoid accidents. Track maintenance was at one time hard manual labour, requiring teams of labourers (US: gandy dancers, UK: platelayers or trackmen, Australia: fettlers), who used lining bars to correct irregularities in horizontal alignment (line) of the track, and tamping and jacks to correct vertical irregularities (surface). Currently, maintenance is facilitated by a variety of specialised machines.

A tie replacement train in Pennsylvania

The surface of the head of each of the two rails can be maintained by using a railgrinder.

Common maintenance jobs include changing crossties (sleepers), lubricating and adjusting switches, tightening loose track components, and surfacing and lining track to keep straight sections straight and curves within maintenance limits.

Spraying ballast with herbicide to prevent weeds growing through and disrupting the ballast is typically done with a special weed killing train.

Rail tracks with vegetation

Flange oilers lubricate wheel flanges to reduce rail wear in tight curves, Middelburg, Mpumalanga, South Africa

Over time, ballast is crushed or moved by the weight of trains passing over it, periodically requiring relevelling ("tamping") and eventually to be cleaned or replaced. If

this is not done, the tracks may become uneven causing swaying, rough riding and possibly derailments.

Rail inspections utilize nondestructive testing methods to detect internal flaws in the rails. This is done by using specially equipped HiRail trucks, inspection cars, or in some cases handheld inspection devices.

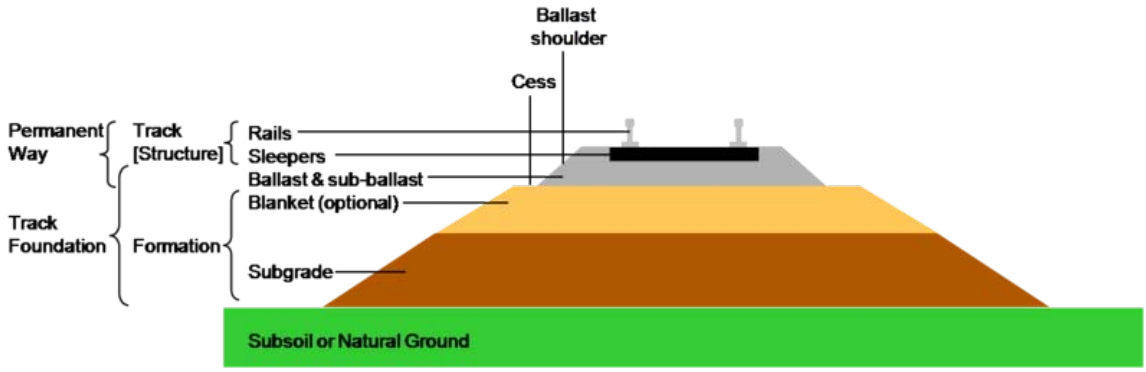
Rails must be replaced before the railhead profile wears to a degree that may trigger a derailment. Worn mainline rails usually have sufficient life to be used on a branch line, siding or stub afterwards and are "cascaded" to those applications.

The environmental conditions along railroad track create a unique railway ecosystem. This is particularly so in the United Kingdom where steam locomotives are only used on special services and vegetation has not been trimmed back so thoroughly. This creates a fire risk in prolonged dry weather.

In the UK, the cess is used by track repair crews to walk to a work site, and as a safe place to stand when a train is passing. This helps when doing work minor work, while needing to keep trains running, by not needing a Hi-railer or transport vehicle blocking the line to transport crew to get to the site.

Track bed and foundation

Railway tracks are generally laid on a bed of stone track ballast or track bed, in turn is supported by prepared earthworks known as the track formation. The formation comprises the subgrade and a layer of sand or stone dust (often sandwiched in impervious plastic), known as the blanket, which restricts the upward migration of wet clay or silt. The track and ballast form the permanent way. The term foundation may be used to refer to the ballast and formation, i.e. all man-made structures below the tracks.



Section through railway track and foundation showing the ballast and formation layers. The layers are slightly sloped to help drainage.

Additional measures are required where the track is laid over permafrost, such as on the railway to Tibet, such as transverse pipes through the subgrade to prevent that subgrade from melting. These pipes allow cold air to penetrate the formation.

The sub-grade layers are slightly sloped to one side to help drainage of water.

Glossary of Rail Terminology

Rail terminology is a form of technical terminology. The difference between the American term *railroad* and the international term *railway* (used by the International Union of Railways and English-speaking countries outside the US) is the most obvious difference in rail terminology. There are also others, due to the parallel development of rail transport systems in different parts of the world.

Various terms are presented here alphabetically; where a term has multiple names, this is indicated. The note "US" indicates a term peculiar to North America, or "CA" may represent Canada while "UK" refers to terms originating in the British Isles and normally also used in former British colonies outside North America (such as Australia "AU", New Zealand "NZ", etc.). The abbreviation "UIC" refers to standard terms adopted by the International Union of Railways in its official publications and Thesaurus.

Exceptions are noted; terms whose currency is limited to one particular country, region, or railway are also included.

0-9

Definitions	Points of Interest
• **10 wheeler** or ten wheeler (US): A steam locomotive with a 4-6-0 wheel arrangement.	

A

Definitions	Points of Interest
• **All weather adhesion**: locomotive adhesion is the ratio of max available Tractive effort to the weight of the locomotive in all weather	

conditions.

- **Air brake**: Railroad brakes which operate using compressed air.
- **Alco**: American Locomotive Company - the second largest builder of steam locomotives in the U.S.
- **Alerter**: Similar to the Dead man's switch other than it does not require the operator's constant interaction. Instead an alarm is sounded at a preset interval in which the operator must respond by pressing a button to reset the alarm and the timer. If the operator does not respond within a preset time the brakes are applied. May also be called a 'Watchdog'.
- **American**: A steam locomotive with a 4-4-0 wheel arrangement.
- **Angel Seat** or Angel's Perch: (US) A term often used when referring to the second level seats on a Cupola style caboose.
- **Annett's key** (UK), **Annett key** (AU): A large key which locks levers or other items of signalling apparatus, serving as a portable form of interlocking. With the key removed from the lock, the lever or apparatus is locked in its position. When the key is turned in the lock, it cannot be removed.
- **Articulated locomotive**: A steam locomotive with one or more engine units that can move relative to the main frame.
- **Aspect**: (UK) The indication displayed by a colour-light signal i.e. a yellow aspect
- **Atlantic**: A steam locomotive with a 4-4-2 wheel arrangement.
- **A unit** (US): A diesel locomotive with a driving cab, or crew compartment, for operating on the road. When equipped with **MU**, it can control other A units, or B units.
- **Auto brake** A type of fail-safe system that uses air pressure to hold the brakes off so that in the event the air pressure is lost in the *brake pipe* the brakes will automatically apply.
- **Auto-brake gauge**: A gauge recording the application and pressure of an automatic braking system; usually repeated in the guard's van in historic rolling stock.
- **Autocoach (UK)**: A passenger coach fitted with a

An **American** class steam locomotive

A Cupola style Caboose. Note the **Angel Seat** above.

An **Automatic Equipment Identification (AEI)** Tag attached to a freight car

A string of TTX **Autorack** cars in service

driving cab and controls for use in an **Autotrain (UK)**.

- **Automatic Equipment Identification (AEI)** (US): Automatic tracking system using RFID technology.
- **Automatic Train Control (ATC)**
- **Automatic train operation (ATO)**
- **Automatic train protection (ATP)**
- **Automatic Warning System** (UK): Refers to the specific form of limited cab signalling introduced in 1948 in the United Kingdom to help train drivers observe and obey warning signals.
- **Autorack (also called *auto carrier*)** (US): A specialized freight car for transporting automobiles. **Car transporter wagon** / **Car transporter van** (UK).
- **Autotrain (UK)**: A branch line train consisting of a steam locomotive and passenger carriages that can be driven from either end by means of rodding to the regulator and an additional vacuum brake valve. The fireman remains with the locomotive and, when the driver is at the other end, the fireman controls the cut off and vacuum ejectors in addition to his usual duties. Also: **Push-pull train, Motor train** (UK).
- **Auto Train (US)**: A passenger train service first operated by Auto-Train Corporation and then by Amtrak between Lorton, Virginia and Sanford, Florida that carries the passengers' automobiles aboard the same train in autoracks.

B

Definitions

- **B unit** (US): A *cabless booster* locomotive, controlled via *MU* from a cab-equipped *A unit*. Sometimes equipped with limited controls for hostling.
- **Bacon slicer** (UK): Slang term for a cutoff controlled by a wheel operating through a worm and nut, rather than the more usual quadrant lever. The device was slow to operate, but very precise, and therefore only fitted to long-distance locomotives where frequent changes of cut-off were not required.
- **Bad order**: A tag or note applied to a defective piece of

Points of Interest

Boom barriers at a railway crossing in France

equipment. Generally, equipment tagged as bad order is not to be used until repairs are performed and the equipment is inspected and approved for use.

- **Baldwin**: American locomotive manufacturer.
- **Ballast**: aggregate stone, gravel or cinders forming the track bed on which sleepers (ties) and track are laid to ensure stability and proper drainage.
- **Balloon**: A looped length of track, usually at the end of a *spur* or *branch*, which allows trains to turn around for the return trip without reversing or shunting. Can be used as part of a freight installation to allow the loading or unloading of bulk materials without the need to stop the train.
- **Bank**: A particularly steep section of line that requires additional bank (or banking) engines (US: helper engines) to help trains climb.
- **Base plate** (UK), *tie plate* (US): An iron or steel plate used to spread the weight of rail over a larger area of sleeper (tie) and facilitate a secure, low maintenance, fastening with bolts or clips. It derives from the former Rail chairs.
- **Bay platform**: A type of platform/track arrangement where the train pulls into a siding, or dead-end, when serving the platform.
- **Beep**: A one-of-a-kind *switcher locomotive* (also referred to as the **SWBLW**) built by the Atchison, Topeka and Santa Fe Railway in 1970.
- **Blastpipe**: A part of a steam locomotive that discharges exhaust steam from the cylinders into the smokebox beneath the chimney in order to increase the draught through the fire.
- **Blower**: On a steam locomotive, a steam pipe leading into the *smokebox*, causing necessary draft in the chimney (stack) when the engine is **not** running. However, UK practice is to turn on the *blower* also when entering tunnels, etc., to avoid dangerous blow-back into the cab. (The UK loading gauge is much smaller than that in the US and the tunnel roof would otherwise spoil the normal draft created from the exhaust.) On a two-stroke diesel engine, the blower is a mechanical device that scavenges the cylinders: not to be confused with a supercharger.
- **Bobber**: (archaic, US): A slang word for a small *caboose* with just four wheels, all rigidly mounted to the frame. This design was common in the 19th century. Bobber refers to the bouncing action of such a caboose while in

A Boxcar (US) Goods van (UK): rolling stock, used to transport freight

BNSF Railway GP60B **B Unit**

An example of a BNSF Railway **bad order** repair tag

A **"Bobber"** 4-wheel *caboose* of the Denver & Rio Grande Railroad preserved at the Colorado Railroad Museum, Golden, Colorado

Bettendorf-type freight car **bogie**; note the solid bearings around the ends of the axles.

motion.

- **Bo-Bo** (Europe): A locomotive with a 4 wheel per truck configuration, each individually powered, as opposed to a 6-wheel "Co-Co" configuration.
- **Bogie**: (chiefly UK) The undercarriage assembly incorporating the wheels, suspension, brakes and, in powered units, the *traction motors*. Generally called a *truck* in the US.
- **Boiler**: A cylindrical container adjacent to the *firebox* in which steam is produced to drive a steam locomotive.
- **Bonds**: Short wires used to bridge gaps in electrical circuits, usually at track circuit joints or between rails.
- **Booking Clerk**: A person at a station whose job is specifically selling tickets.
- **Boom barrier**: A barrier at a level (rail) crossings.
- **Booster**: (Steam locomotive) - An extra set of *cylinder*s that can be engaged to drive a trailing truck or tender truck to give additional *tractive effort* at starting and low speeds.
- **Boxcar** (US): a type of rolling stock with a flat bottom enclosed on all sides and top, which is loaded and unloaded from sliding doors on each side. Same as van (UK).
- **Brakeman** (US): A train crew member who performs *railcar* and track management; often a single job description along with switchman ("brakeman/switchman"). A brakeman manually activated brakes on *railroad cars* before the advent of air brakes.
- **Brakeman's cabin**, **brakeman's cab** or **brakeman's caboose** (US): small hut at one end of a railway wagon to protect the brakeman from the elements.
- **Brake Pipe** (US): The main air pipe of the trains pneumatic braking system.
- **Brake van** (UK): A heavy vehicle with powerful brakes which was attached to the rear of goods trains in the days when most wagons were not fitted with a continuous braking system. Its function was to supplement the locomotive's braking power in slowing and stopping the train and to keep the couplings uniformly tight by selective light braking to avoid snatching and breakages. It also conveyed the train guard, hence its alternative name of *"guards van"*. Partly analogous to *caboose* and its synonyms.
- **Branch line**: A secondary railway line that branches off a main line.

A CSX cab version of a Diesel-electric *Slug'* often called a **Booster Unit**; note the missing radiator and the one piece side panels in lieu of door panels.

- **Broad gauge**: Track where the rails are spaced more widely apart than 1,435 mm (4 ft 8 ½ in) (which is called standard gauge). Many early railroads were broad *gauge*, for example the Great Western Railway in the UK which adopted 7 ft 1/4 in (2141 mm) *gauge* until it was converted to *standard gauge* in the 1860s - 1890s. Russia still has over 80,000 km of broad gauge (1520 mm or 5 ft) railroads. Broad *gauge* is also normal in Spain, Portugal, and India (1680 mm or 5 ft 6 ins), as well as Ireland and used in some parts of Australia (1600 mm or 5 ft 3 ins).
- **BRUTE**: British Rail Universal Trolley Equipment - type of platform trolley found on stations all over the UK rail network from the late 1960s to the early 1980s.
- **Bubble Car**: A DMU consisting of a single coach (UK), e.g. British Rail Class 121
- **Buckeye coupler**: A form of *coupler* which will lock automatically when the two parts are pushed together.
- **Buck** (US): A term used for pushing railroad cars with a locomotive then allowing them to roll under their own momentum into a siding. (Assuming a brakeman hangs on for a free ride) Also; *Kick*.
- **Buffer** A device that cushions the impact of rail vehicles against each other.
- **Buffer stop**: The barrier installed at the end of a dead end track to prevent rail vehicles from proceeding further.
- **Bull head rail** (UK): A steel rail section commonly used in 60 ft lengths on almost all railway lines throughout Britain until c1950, which due to its shape must be supported in cast iron chairs that are screwed to the sleepers. It is still found on secondary and preserved lines and in yards. The rail has two heads (shaped somewhat like a vertical dumbbell) so, when one side became worn, the rail could be inverted and reinstalled for further service rather than being replaced.
- **Bustitution**: The practice of replacing train service, whether light rail, tram/streetcar systems, or full-size railway systems, with a bus service, either on a temporary or permanent basis. Somewhat derogatory and mainly used in the UK, Canada, USA, and Australia. The word is a portmanteau of the words "bus" and "substitution".

C

Definitions

- **Cabin car** (PRR).
- **Cabless**: A locomotive without a cab. Commonly referred to as a *B unit* or a *Slug*. Although not all *Slugs* are cabless.
- **Caboose**: A railroad car attached usually to the end of a train, in which railroad workers could ride and monitor track and rolling stock conditions. Partly analogous to *brake van* (UK). Largely obsolete, having been replaced by the electronic End of Train *(EOT)* device, or *Flashing Rear End Device* called *"FRED"*.
- **Cant**: Angle. Can be used in the context of the cant of the track (the relative level one rail to another, e.g. on curves) (UK); and the cant of a rail, being the angle of an individual rail relative to vertical.
- **cape** (UK): To note the cancellation of a passenger train service to employees. (From British Railways telegraphic codeword)
- **Carbody unit** or **cab unit** (US): A locomotive which derives its structural strength from a bridge-truss design framework in the sides and roof, which cover the full width of the locomotive. It refers to both A units and B units.
- **Carman** (US): A mechanic responsible for maintaining and inspecting the rolling stock.
- **Catenary** or **catenary structure**: The overhead wire system used to send electricity to an electric locomotive or *multiple unit*, tram or light rail vehicle.
- **Centralized traffic control (CTC)** (US, AU): A system in which signals and switches for a given area of track are controlled from a centralized location. May or may not be computerized.
- **Cess** (UK): The area either side of the railway immediately off the ballast shoulder. This usually provides a safe area for workers to stand when trains approach.
- **Chair** (UK): A cast iron bracket screwed to the sleeper and used to support bull head rail that is held in place by a wooden key (wedge) or spring steel clip. Still found on preserved railways and in yards.
- **Ches-C** (US): Chessie System's kitten logo.

Points of Interest

A Conrail 'Bay window' **caboose** on display at the National New York Central Railroad Museum

A *cess* along the London Underground

An electric Amtrak train with two AEM-7 locomotives running through New Jersey on the Northeast Corridor. The **catenary** system is clearly visible.

- **Chimney** (UK): Smokestack or stack (US), or funnel.
- **Co-Co** (EU): A heavier duty locomotive with 6 wheels per bogie (all axles being separately driven) configuration as opposed to a 4-wheel "Bo-Bo" configuration. The correct classification is Co'Co', but Co-Co is used more often.
- **COFC**: Abbreviation for "Container On Flat Car".
- **Colour light signal**: A signal in which the colour of the light(s) determine the meaning of the aspect shown.
- **Colour position signal**: A signaling system that uses both colour and light position to determine the meaning of the aspect shown.
- **Combined Power Handle**: A handle or lever which controls both the throttle and the dynamic braking on the locomotive: forward (away from operator) past center is throttle up, backward (toward operator), past center, operates the dynamic brake.
- **Composite** (UK passenger car): A passenger car with more than one class of accommodation provided, e.g. First and Third. In earlier days of three-class travel, First and Second class, and Second and Third class composites were also built. A car with First, Second and Third classes was also known as a tri-composite.
- **Compound locomotive**: A steam locomotive passing steam through two sets of cylinders. One set uses high pressure steam, then passes the low pressure exhausted steam to the second.
- **Compromise joint**: A special joint bar used to join rail ends of two different cross-sections while holding the top running surface and inside gauge surface even.
- **Conductor** (US), guard (UK): The person "in charge" of a train and its crew. On passenger trains, a conductor is also responsible for tasks such as assisting passengers and collecting tickets. In Australia, both terms are used, "conductor" for the person checking tickets, etc. on a tram or train, and "guard" for the person in charge of the train.
- **Consist** (US), formation (UK): A noun to describe the group of rail vehicles making up a train, or more commonly a group of locomotives

An AAR Type "E" railroad car **coupler** (US)

An Amtrak EMD F40PH is one of many **Cowl units**

connected together for Multiple-Unit (MU) operation.

- **Continuous welded rail (CWR)**: In this form of track, the rails are welded together by utilising the thermite reaction or flash butt welding to form one continuous rail that may be several kilometres long.
- **Control car** or **Cab car**: A passenger coach which has a full set of train controls at one end, allowing for the use of push-pull train operation.
- **Control Point** (**CP**) (US): An interlocking, or the location of a track signal or other marker with which dispatchers can specify when controlling trains.
- **Cornfield meet** (US): A head-on collision between two trains.
- **Coupler** (US), coupling(UK): Railroad cars in a train are connected by couplers located at the ends of the cars.
- **Coupling rods** or **connecting rods**: Rods between crank pins on the wheels, transferring power from a driving axle to a driven axle of a locomotive.
- **Cow and calf**: A diesel locomotive with a crew cab permanently coupled to and acting as a controller for a similar slave diesel locomotive without a crew cab, primarily used for switching/shunting duties for large groups of rolling stock. Also known as *master and slave*, as in the British Rail Class 13 shunters at Tinsley Marshalling Yard.
- **Cowl unit** (US): A locomotive whose sides and roof are non-structural, and cover the full width of the locomotive. Structural strength comes from the underframe.
- **Crank pin**: A pin protruding from a wheel into a main or coupling rod.
- **Crew driver** (US): Person(s) operating ground transportation vehicles for transporting railroad crews to and from various locations.
- **Crosshead**: The pivot between the *piston* rod and the main rod on a *steam locomotive*.
- **Cross-tie** (U.S): sleeper (UK).
- **Cut off:** A variable device on steam locomotives which closes the steam valve to the steam cylinder before the end of the piston stroke, thus

conserving steam while allowing the steam in the cylinder to expand under its own energy. Also: Reverser.

- **Cutting**: A channel dug through a hillside to enable rail track to maintain a shallow gradient.
- **Cylinder**: The central working part of a reciprocating engine, the space in which a piston travels.

D

Definitions

- **Dark territory** is a section of track not controlled by signals.
- **Dead man's handle** or **Dead man's switch**: A safety mechanism on a train controller which automatically applies the brake if a lever is released. It is intended to stop a train if the driver is incapacitated. In some forms, this device may be pedal-actuated.
- **Deadhead**: (US) 1. A nonrevenue (i.e., nonpaying) passenger. Often this is a railroad employee traveling on assignment. 2. To move locomotives or rolling stock in nonrevenue service.
- **Defect detector**: A track side device used to detect various defects such as Hotboxes (Overheated axle bearings), dragging equipment, leaning cars, overloaded cars, overheight cars, seized wheels, etc.
- **Demurrage** A charge levied by a railroad to a shipper for excessive delay in unloading cargo.
- **Derailer**, a safety device that will derail vehicles passing it.
- **Detonators**: Small charges placed on the running rail which explode when run over; used to warn drivers in following trains of an incident ahead. Also called **torpedoes** (US).
- **Diamond**: Trackage which allows a rail line to cross another at grade.
- **Diesel multiple unit** or DMU: A set of diesel-powered self-propelling passenger rail vehicles able to operate in multiple with other such sets. Such units, especially those consisting of a single vehicle, are sometimes termed **railcars**.

Points of Interest

Detonator on rail in South Africa

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Railroad crossing at grade, also known as a **diamond**. This example is located in Mulberry, Florida.

- **Direct Traffic Control (DTC)**: A system in which train dispatchers communicate directly with train crews via radio to authorize track occupancy in predefined blocks.
- **Ditch lights**: A pair of lights, usually found on modern locomotives, located several feet below and outboard of the main headlight, that may alternately flash when the train is sounding its horn.
- **DOO**: Driver-only operation, also referred to as One person train operation (OPTO).
- **Doodlebug**: Gasoline-electric self-powered passenger car used for small capacity rural commuter service. Also a British Rail Class 153 DMU.
- **Double**, as in "Double the hill": if a train has insufficient power to climb a grade and no helpers are available, the train will be split into two sections and run separately to the top.
- **Down**: (UK) A direction (usually away from London, other capital city, or the headquarters of the railway concerned) or side (on left-running railways, the left side when facing in the down direction). The opposite of **up**. The down direction is usually associated with odd-numbered trains and signals. In Australia it is used relative to the state's capital city. US railways use the compass points northbound, southbound, eastbound and westbound.
- **Dragging equipment detector**:
- **Drift** Cutting off power and allowing a train to coast.
- **Driver** (UK), Engineer (US): The operator of a railway/railroad locomotive.
- **Driver** (UK): Steam locomotive driving wheel, particularly in "single driver" (one driven axle) engines.
- **Driving Van Trailer** or DVT (UK): A class of control cars used in the UK.

E

Definitions

- **Ejector**: Component of vacuum brake system. Steam passing through a cone sucks air from the train pipe to create the vacuum. Usually fitted in pairs: a small ejector running continuously to overcome leaks and to restore the vacuum after light braking and a large ejector operated when needed to release the brakes quickly after a heavy application or to create the initial vacuum ("making a brake" – UK) after coupling up.
- **Electric multiple unit (EMU)**: A set of electrically powered self-propelling passenger rail vehicles able to operate in multiple with other such sets.
- **Elephant style** (US) - Railfan jargon to describe how multiple locomotives are coupled together in a train; the front of the second locomotive is coupled to the rear of the first locomotive, the front of the third locomotive is coupled to the rear of the second locomotive, and so on down the line. The term is reminiscent of a parade of circus elephants where the elephant behind the front elephant would hold the leading elephant's tail in its trunk.
- **Elevated railway**: One typically built on supports over city streets, commonly called "*the el*" or simply the "*The L*".
- **Embankment**: A raised pathway on which rail tracks are placed to maintain a shallow gradient when passing over depressions in the terrain.
- **Empty Coaching Stock** train, or **ECS**: A train used to bring carriages into (or out of) service. They usually run between sidings and main stations, with the carriages then forming a service train to another destination. They are often worked under freight train rules - *e.g.* without needing a guard in the UK.
- **EMD**: Electro-Motive Diesel, Inc, the world's second largest builder of railroad locomotives. EMD was previously Electro-Motive Division of GM before being sold.
- **Engineer** (US), driver, engine driver, train driver (UK): The operator of a locomotive.
- **EOT** (US): End of train device. A form of an *electronic caboose* also called *FRED*.
- **EP gauge** (UK): Electro-pneumatic brake gauge; recording the application and pressure of the service brake, usually repeated in the guards van in historical rolling stock.

Points of Interest

Three BN locomotives coupled **elephant style**"

- **Event recorder** - A device that continuously captures analog and digital train systems information and stores that data for a minimum of 48 hours. This data is used to evaluate incidents and accidents. Typical stored data includes speed, brake pressure, dynamic brake, horn activation, track signal, etc. In the U.S., event recorders are mandated by the Federal Railroad Administration (FRA) for freight, passenger and commuter rail. Regulations for railroad outside the U.S. vary by country. Transit operations are not generally required to have event recorders, but have begun to add them voluntarily.
- **Ex-con** (US): An ex-Conrail locomotive (jargon) or former employee of Conrail. Not to be confused with the more common meaning of a convicted criminal who has been released after serving prison time.
- **Express train**: A train that passes selected stations without stopping.
- **Extra train**: A train that is not included in the normal schedule of a railroad. In train order territory, extras are required to clear the main line for scheduled trains to pass.

F

Definitions

- **Facing**: A turnout is facing if it can select which way to diverge a train. Opposite of trailing.
- **Fairlie**: A type of articulated locomotive, typically (but not exclusively) with two boilers and connected fireboxes in a central cab.
- **Fall plate**: A heavy, hinged steel plate attached in a horizontal position to the rear of the locomotive footplate or front of a locomotive tender. When the tender is attached to its locomotive the plate is allowed to fall to cover the gap in the "floor" between the two units. The sliding edge is not fixed and has a smooth chamfer so as to avoid a trip hazard.
- **Fallen flag** (US): A railroad which is defunct, having either merged or discontinued operations.
- **Feedwater heater**: A device to preheat the water for a steam locomotive; improves efficiency.
- **Fettle**, **fettling**: Making repairs to rail track, especially concerned with maintaining the drainage of the ballast, and the proper cant of the rail track and rails.
- **Fiddle Yard**: A concealed group of sidings used in

Points of Interest

A train of loaded **flatcars**

Four-quadrant gates at Chertsey, England. The gates are rising.

model railways to provide more realistic operation in limited space.

- **Firebox**: In steam railroading, a firebox was a chamber in which a fire would produce sufficient heat to create steam once the hot gases from the firebox were carried into the adjacent boiler via tubes or flues.
- **Fireman** *(also **Stoker, Boilerman**):* A worker whose primary job is to shovel coal into the firebox and ensure that the boiler maintains sufficient steam pressure; a driver's assistant.
- **Fishplate** (UK), Joint bar (US): A metal plate that joins the ends of rails in jointed track.
- **Flat**: A wheel defect where the tread of a wheel has a flat spot and is no longer round; flats can be heard as regular clicking or banging noises when the wheel passes by. This is caused either by a locked bearing, or a brake that was not fully released before the car was moved, dragging the wheel without turning.
- **Flatcar** (US): A type of rolling stock, which can be a flat-bottomed car with no sides on which freight (including intermodal containers) can be stacked. A bulkhead is a flatcar with walls on the front and rear. A center-beam bulkhead is a bulkhead flatcar with an additional wall dividing one side of the flatcar from the other, but still without any sides. **Flat wagon** (UK).
- **Flying junction**, **Flyover**: A railway junction that has a track configuration in which merging or crossing railroad lines provide track connections with each other without requiring trains to cross over in front of opposing traffic.
- **Foamer** (US): A colloquial term for a railfan, specifically one whose enthusiasm is excessive, "foaming at the mouth".
- **Four-foot**: The part of the line between a pair of running rails. An abbreviation for *four foot, eight-and-a-half-inches.*
- **Four-quadrant gate**: A type of Boom barrier, see above.
- **FRA**: (US) The Federal Railroad Administration. This agency oversees rail operation regulations and safety requirements for U.S. freight, passenger and commuter rail operations.
- **Flashing Rear-End Device (FRED)** (US): A small marking device with a flashing red light mounted on the end of the train. FRED also monitors various train functions such as brake pipe pressure, motion and GPS location. A form of an electronic caboose. Also called an *EOT* (end of train) device.

A **FRED** — Flashing Rear-End Device

A brakeman uses a **fusee** to demonstrate a hand signal indicating "stop"

- **Free-mo**: A type of modular layout in model railroading.
- **Freight** (US) **Goods** (UK): the product(s) in which are carried.
- **Frog**: (US) A casting with "X" shaped grooves used in *switches* and *crossovers*.
- **Funnel**: A Thomas the Tank Engine misnomer for a chimney (UK) or smokestack (US), although it is also used in Australia (Victoria at least). Some early steam engines had a smokestack consisting of a straight vertical flue and a funnel-shaped top, probably leading to the use of "funnel" to describe the entire stack.
- **Fusee**: A pyrotechnic device similar to an automotive flare that is used for signalling.
- **Fusible plug**: A threaded plug, with a soft metal core, that is screwed into the crown plate of a firebox. If the water level gets too low the core melts and the noise of the escaping steam warns the enginemen.

G

Definitions

- **Gage**: An alternate (US) spelling of "Gauge" as in "track or rail gage".
- **Gandy dancer** (slang, US): A track maintenance worker.
- **Garratt**: A type of articulated locomotive.
- **Gauge**: The width between the inner faces of the rails.
- **Geep**: A slang term for any of the GP ("general-purpose") series of Electro-Motive four-axle diesel locomotives; originally applied only to EMD GP7, GP9, and GP18 models.
- **Glad hand** A quick-coupling/uncoupling connector at the end of a trainline air hose that resembles a pair of "shaking hands" when hoses are connected.
- **Go-devil**: A hand-powered railroad car, or a small gasoline powered railroad car .
- **Gondola**: A type of rolling stock with a flat bottom and relatively low sides, used to haul material such as ore or scrap, and loaded and unloaded from the top. May be covered or uncovered. Open wagon (UK).
- **Goods** (UK): **Freight** (US): Both terms are used in Australian English
- **Goods wagon** or **Goods van** or **Goods truck** (UK): **Freight car** or Box car (US): A flat car with sides and a top, usually with a large sliding door in the middle of each side.

Points of Interest

A **Garratt** locomotive

An EMD GP38-2, "General Purpose" (GP) locomotives are often called a **"Geep"**

A **Gondola** type of railroad car

- **Grab bar**: A handle on the side of a car to allow switching personnel to hold on (also known as a "grab iron").
- **Green**: A colour associated with go or proceed.
- **Guard** (UK): Conductor (US).
- **Guard rail** (US) **Check rail** (UK): A double rail section of track, sometimes found in train yards and on bridges to prevent derailments or limit damage caused by derailments , by having rail on both sides of the wheel flange. Also found on curves with a tight radius and switches and crossings
- **Gunzel** (AU) Railway enthusiast. In Melbourne, Victoria it often refers to tramway enthusiast.

H

Definitions

- **Hack** (slang, US): A caboose, since it carried the crew around like a taxicab.
- **Hammerhead style** (slang, US): The practice of running a Diesel locomotive with its long hood forward. This has been done for a variety of reasons, such as crew safety in case of a collision. On short runs, operating the locomotive "backwards" is more economical than using a wye or turntable or operating a second locomotive. Some locomotives may have a second control stand to facilitate operation in the "reverse" direction.
- **Handcar**(US), A small, hand-powered railroad car used for track inspection. Pump trolley (UK).
- **Head end power** or HEP: A scheme whereby the locomotive engine or a separate generator provides 'hotel' power to carriages.
- **Headboard**. A sign attached to a locomotive to identify a named train or tour/charter, or for other special occasions.
- **Headshunt** (UK), Shunting neck (US): A length of track feeding a number of sidings that permits the sidings to be shunted without blocking the main line, or where two lines merge into one before ending with a buffer, to allow a *run-round* procedure to take place.
- **Heavy haul**: Heavy freight operations.
- **Heavy rail** (US): A city-based transit rail system that runs on its own dedicated track and often underground. Subways are considered heavy rail. Refers to commuter rail and inter-city rail when used by the FRA or in other countries.

Points of Interest

A **handcar** (pump trolley UK)

TPW 400, an ALCO RS-11, a type of **hood unit**

- **Heavyweight** (US): During the period between about 1910 and the mid nineteen thirties, most passenger cars in the US were built with three axle trucks, concrete floors, and riveted, double walled sides and often weighed 90 - 100 tons or more. Heavyweight construction was used to improve ride quality.
- **High rail**: The upper rail in a curve or superelevation which typically experiences the higher lateral loads and greater wear.
- **Hit the ground** (slang): To derail
- **Hogger** (slang, US): A locomotive engineer.
- **Hole, the**: A passing siding. Inferior trains "lay over in the hole" to let superior ones pass.
- **Hoodlebug** (slang, US): A small commuter passenger train or trolley.
- **Hood unit** (US): A locomotive whose sides and roof are nonstructural and do not extend the full width of the locomotive. Structural strength comes from the underframe.
- **Horn blocks**: Plates lining the axlebox cut-outs in a locomotive frame to allow smooth vertical movement under control of the springs.
- **Hotbox**: An axle bearing that has become excessively hot due to friction.
- **Hotbox detector**: A device attached to the track which monitors passing trains for hot axles, and then reports the results via a radio transmission (US) or a circuit to the signal box (UK).
- **Hotel power** (US): Electric power used to provide for the comfort of passengers aboard a train en-route.
- **Hot rail** (US): 1. Any section of track over which a train movement is imminent. The closer and/or faster the approaching train, the "hotter" the rail. 2. On some electrified railroads and rapid transit lines, the third rail which supplies power to locomotives or cars.
- **Hotshot** (US): A fast, long-distance train given priority on the track over other trains.
- **Hump**: A raised section in a rail sorting yard that allows operators to use gravity to move freight railcars into the proper position within the yard when making up trains of cars (that is, humping the cars). This is faster and requires less effort than moving cars with a switching engine.
- **Hunting**: Swaying motion of a railway vehicle or bogie caused by the coning action on which the directional stability of an adhesion railway depends. The truck or bogie wanders from side to side between the rails,

"hunting" for the optimum location based on the forces at play.

I

Definitions

- **Infill station** (sometimes **in-fill station**): A train station built on an existing passenger line to address demand in a location between existing stations.
- **Injector**: A device to force water into a steam locomotive's boiler by steam pressure.
- **Interlocking** (US): Any location that includes a switch or crossing of two tracks, derived from the early practice of installation of a system of mechanical equipment called an *interlocking plant* to prevent collisions. **Interlocking** is also the term for the actual mechanical or electrical apparatus that prevents switch/points and signals from being operated in ways that would allow for conflicting train movements.
- **Intermodal**: Moving goods or people by more than one type of vehicle. Intermodal freight can be transported using shipping containers which can easily be transferred among railroad *flatcars*, ships, airplanes, and tractor-trailer trucks.
- **IRJ**, **IBJ**: Insulated rail joint/insulated block joint. Rail joints incorporating insulation to isolate individual track circuits.
- **Island platform**: A railway platform that has tracks along the full lengths of both sides.

Points of Interest

The **interlocking** tower and tracks at Des Plaines, Illinois, in 1993

Intermodal ship-to-rail transfer of containerized cargos at APM Terminals in Portsmouth, VA.

J

Definitions

- **Jack**: A dwarf signal (slang, Boston and Maine and New York New Haven and Hartford Railroads)
- **Jerk a lung** (North America): To break a train in two, usually by shearing the knuckle pin in a coupler, often caused by the application of excessive head end power. Example: "The engineer jerked a lung on the upgrade."
- **Johnson bar** (US): On a locomotive, a long, heavy lever that operates the cutoff, etymology unknown.
- **Joint bar**, **fishplate** (UK): Joins the ends of rails in jointed track. Also referred to in North America as a rail joiner or angle bar.
- **Jointed track**: Track in which the rails are laid in

Points of Interest

journal bearing

Journal box

lengths of around 20 m and bolted to each other end-to-end by means of fishplates (UK) or joint bars (US).
- **Journal bearing**: a bearing without rolling-elements
- **Journal box**, the housing of a journal bearing.
- **Junction**: A point at which two lines or separate routes diverge from each other.

Clapham **Junction** Railway Station. Acute end of the Railway Junction London, England.

K

Definitions

Points of Interest

- **KE**: (Kinematic Envelope) The outline of the space beside and above the track that must be kept clear of obstructions for the train to pass. This can be larger than the static clearance around an unmoving engine or car.
- **Key** (UK): Timber or sprung steel block used to secure Bullhead rail into the chairs.

L

Definitions

Points of Interest

- **Lantern** (US) **Lamp** (UK/AU): A portable (often handheld) light source that is used to signal train crews.
- **Leaner** (US): (slang) A car in which the load has shifted, or it has been improperly loaded, or a mechanical failure has occurred that causes the car to lean to one side. This could potentially cause a collision or derailment.
- **Level crossing**: a crossing on one level ("at-grade intersection") — without recourse to a bridge or tunnel — generally of a railway line by a road or path (also called a railroad crossing, railway crossing, train crossing or grade crossing (US)). The term is sometimes used for a crossing by (not a junction with) another rail track (known as a **flat crossing** in the UK).
- **Level junction** (US), **Flat junction** (UK): A junction in which all track crossings take place at grade and routings must therefore be controlled by signals and interlocking.
- **Light engine**: A locomotive travelling on its own, or perhaps with just a caboose (brake van) attached.
- **Light rail**: A city-based rail system based on tram design

A brakeman's **lantern** from the Chicago and North Western Railway; this lantern

standards that operates mostly in private rights-of-way separated from other traffic but sometimes, if necessary, mixed with other traffic in city streets. Light rail vehicles (LRV) generally have a top speed of around 55 mph (89 km/h) though mostly operating at much lower speeds, more akin to road vehicles. Light rail vehicles usually run on trackage that weighs less per foot (due to a smaller track profile) than the tracks used for main-line freight trains; thus they are "light rail" due to the smaller rails usually used.

- **Local train**: A train that stops at most, if not all, stations along its route. Often referred to in North America as a "milk train" or "milk run" (usage from the days when trains stopped at every station and stop along their route to pick up fresh milk brought to the stations daily from local dairy farms).
- **Location case** (UK): A trackside cabinet used to house signalling equipment such as relays or transformers.
- **Loop** (UK), siding (US): Used on single-track railway lines, a loop is a second parallel track (running for a short distance), allowing two trains to pass by one another.
- **Lunar**, as in lunar white, is a color of Railway signal light. It is an off-white color, achieved by the use of a clear lens of very light blue, to make it distinct from a light that has a broken lens. In UK practice, it is the color used for the type of junction indicator known as a **feather**, so-called for its resemblance to a popular inn sign.

burned kerosene to produce light.

M

Definitions

- **Mainline** or **Main line**: The principal artery of a railway system.
- **Main rod** (US): The drive rod connecting the crosshead to a driving-wheel or axle in a steam locomotive. **Connecting rod** (UK).
- **Maintenance of way** (US): The maintenance of railroad rights of way, including track. Often abbreviated to MOW (as in MOW car).
- **Mallet** (pronounced "mallay"): type of articulated locomotive designed by Anatole Mallet.
- **Matchbox tank** (UK slang): a type of pannier tank where the tanks are square and do not rest of the locomotive frame.

Points of Interest

A Spiker part of a fleet of **Maintenance of way** vehicles

- **Mating worms** (US): Penn Central logo (jargon/slang).
- **Mechanical semaphore signal**: A signal in which the aspect is conveyed by moving an arm.
- **Merry-go-round** (**MGR**) train (UK): coal train running between a coal mine and a power station, loading and unloading without stopping or shunting.
- **MLW**: Montreal Locomotive Works, bought by Bombardier and closed.
- **Mogul**: A steam locomotive with a 2-6-0 wheel arrangement.
- **Motion** (UK): Collective term for the connecting rod, coupling rods and valve gear; forms part of the running gear. Originally from Watt's invention of the *parallel motion*.
- **Motor train** (UK).
- **Multiple aspect signalling**: A system of colour-light signalling in which signals may show 3 or 4 aspects.
- **Multiple unit** (UK) MU (US): a self-propelled rail vehicle that can be joined with compatible others and controlled from a single driving station. The sub-classes of this type of vehicle; Diesel Multiple Unit (DMU), Diesel-Electric Multiple Unit (DEMU) and Electric Multiple Unit (EMU) are more common terms. These may also be termed railcars.
- **Multiple-unit train control** (US), Multiple working (UK): generally seen as the abbreviation MU, this normally refers to the ability of diesel and electric locomotives or multiple units to be joined together and controlled from one driving station. Such a set of joined locomotives is called (US) a consist or (colloquially) "lash-up" and is said to be "MUed together".
- **Multiple working** (UK).

N

Definitions

- **Narrow gauge**: Railroad track where the rails are spaced less than 1,435 mm (4 ft 8 ½ in) apart. There are many common gauges narrower than standard, amongst them 3 ft 6 in (1,067 mm) widely in Africa and Asia; 3 ft (914 mm), which was the most common narrow gauge in the U.S.; 2 ft 6 in (762 mm), used in various locations across Europe, Asia and elsewhwere, South America and Australia, and 2 ft (610 mm), which saw widespread use in the UK. Meter gauge

Points of Interest

Comparison between standard gauge (blue) and one common **narrow gauge (red) rail spacing**

1,000 mm (3 ft 3 ⅜ in) is also widely used in Asia and Africa. Narrow-gauge lines are often found in mountainous terrain where the cost savings of building a smaller railroad can be considerable. (Historically, the term "narrow gauge" was once used in Britain for what is now called standard gauge, as the only other gauge then in common use was the Great Western Railway's 7 ft 0 ¼ in (2,140 mm) broad gauge.)

O

Definitions

- **Open wagon** (UIC, UK), Gondola (US). A form of freight hauling car for bulk goods.
- **ORER** Official Railway Equipment Register.
- **Overbridge** (UK): A bridge over the railway.
- **Overlap** (UK): A distance (normally 180 metres or set according to the permitted speed of the line) beyond a stop signal which must be clear before the preceding stop signal can display a proceed aspect; allows a margin in case a train overshoots a signal before stopping.

Points of Interest

Open wagon Gondola style freight car

P

Definitions

- **P-train**: An NMBS/SNCB commuter train.
- **Pacific**: A steam locomotive with a 4-6-2 wheel arrangement.
- **Pannier tank**: A tank locomotive with the water tanks mounted on the boiler like panniers.
- **Pantograph**: An arm to pick up current from overhead lines.
- **Per diem**: A fee paid by a rail company to the owner of a car (US) (wagon (UK)) for the time it spends on the company's property; also an authorized living expense payment for some workers forced away from their home terminal. Pronounced by some U.S. railroaders *per die-um,* not *per dee-um.*
- **PICOP** (UK): Person In Charge Of Possession – the railway or contractor's official responsible for safe working during engineer's possession.
- **Piston**: The moving component in the cylinder of a steam engine or internal combustion engine that translates into motion the force exerted by pressurised steam or exploding fuel.

Points of Interest

A push pole

- Point machine (UK): A motor or device which operates points.
- **Points** (UK): switch (US). Also "turnout".
- **Pony truck**: A two-wheel truck (US) or bogie (UK) at the front of a locomotive.
- **Porter**: A Porter had various roles: A **Baggage Porter** assisted with luggage; an **Operating Porter** assisted with Safeworking duties; a **Station Porter** assisted with general station duties and a **Lad Porter** was a junior Station Porter.
- **Position light signal**: A signal in which the position of the lights determine the meaning of the aspect shown.
- **Pound (rail)**: Term describing the weight (and thus the cross section) of a length of rail. A heavier rail can carry heavier loads with less distortion and less damage to the rails themselves and the roadbed.
- **Power**: A slang term referring to a locomotive or group of connected (MU'd) locomotives serving as the motive power for a train (as in "the hostler brought the power to the service pit.")
- **Prairie**: A steam locomotive with a 2-6-2 wheel arrangement.
- **Pull-apart**: A rail broken from cold-related contraction.
- **Push pole**: Push pole about 12 feet (366 cm) long and having a diameter of 5 inches (127 mm). They were placed in receptacles called **push pole pockets**. The pole was placed between the locomotive and the freight car, and used to push the car on or off a siding or to another track. Used between 1870 and the mid 1960s.
- **Push-pull**: A mode of operation whereby a locomotive-hauled train may be driven with the locomotive at the front, middle or back of the train. Also: Auto train (UK), above.

Q

Definitions	Points of Interest

R

Definitions	Points of Interest

- **Railbus**: A passenger rail vehicle (typically non-articulated or rigid frame) that was derived from bus propulsion and construction technology, but which may evolve into larger dimensions, performance and characteristics similar in appearance to a light DMU Railcar
- **Railcar**: A powered single unit or articulated passenger car, usually "railroad-derived" light DMU or EMU, with a driver's cab at one or both ends.
- **Railfan**: A hobbyist or enthusiast of trains (q.v. "Foamer").
- **Rail grinder**: a machine used to remove irregularities in the surface of the rails. May be self powered or part of a consist.
- **Rail profile** The cross section shape of rail. There are many rail profiles which are often specific to individual railroads. Rails need to be periodically scanned electronically, the data inspected and analysed, then re-profiled with rail grinding machines to maintain the safe and proper "rail profile". Rails that cannot be brought back to the proper rail profile are condemned and replaced.
- **Railroad car**: A railroad vehicle that is not a locomotive.
- **Railroadiana**: Artefacts of railways around the world.
- **Rail sled** (US): A form of wheel chock that slips onto the rail under the wheel of rolling stock which prevents the vehicle from rolling.
- **Rail Tractor**: A small petrol (gas) or diesel shunting (switcher) locomotive.
- **Railway line** may refer to:
    - A railway route connecting two or more places or other railway routes.
    - A railway route constructed by an organization, usually one formed for that purpose.
    - A railway route which has been given the line name officially (e.g. by ELRs in the UK).
    - A set of railway routes which are bundled for publicity purposes by, e.g., a UK TOC.
    - A set of railway routes without official standing, on which railfans have bestowed a title.
- **Railway station** : A train station.
- **Rake**: (UK) A group of passenger coaches coupled together.
- **Red**: A colour generally associated with stop, when shown by signals or flags.
- **Reefer**: A refrigerated railcar, used to transport

A **Railroad Station**. Union Station, Washington D.C.

Rerail Frog or rerailer at the Saskatchewan Railway Museum

Platform track and run-round loop at Toyooka Station, Hyōgo, Japan, the terminus of the line from Miyazu

perishable goods.

- **Rent-a-Wreck** (slang, U.S.): A (usually old) locomotive owned by a leasing company.
- **Reporting mark**: A two- to four-letter code, assigned by the Association of American Railroads, that is applied to equipment operating on North American railroads to identify the owner.
- **Rerail frog** or **rerailer** a metal casting slotted over the rail near the wheel of a derailed train car. The engine then pushes or pulls the car so that the derailed wheel runs up the rerailer and back onto the track.
- **Reverser** or **Reverser handle**: the handle that controls the directional control on a locomotive
- **Ribbon Rail**: Continuously welded rail.
- **Right-side failure**: A failure in a signalling or other safety critical system which leaves the system in a safe condition.
- **RoadRailer**: A highway trailer, or semi-trailer, that is specially-equipped for direct use on a railroad.
- **Roll-by**: (US; also "Rollby") Visual inspection of a passing train by personnel on the ground for defects or dragging equipment.
- **Rolling stock**: (UK) A railway vehicle that is not a locomotive; 'railway car'. (US) Any railroad car and/or locomotive.
- **Run-round** (runaround (US)): the practice of detaching a locomotive from its train, driving it to the other end of the train and re-attaching it, to allow the train to proceed in the direction it has just come from (e.g. when it reaches its destination and forms a service in the other direction).

S

Definitions

- **Saddle tank**: A tank locomotive with the water tank mounted on top of the boiler like a saddle.
- **Safety Appliance Act** (US): A law mandating air brakes, grab bars, and automatic couplers
- **Safeworking**: The system of rules and equipment designed to ensure the safe operation of trains.
- **Sand**: granular material poured on the rail in front of the drive wheels to improve traction. *(Sandite is a more specialised form for a similar purpose.)*
- **Sandbox**: A container on locomotives and self-propelled multiple units, or trams, that run on tramways and adhesion railways. The container holds sand which can be dropped on to the rail to improve rail adhesion under wet, steep or slippery rail conditions. The sandbox and operating mechanism are collectively known as 'sanding gear'.
- **Sandite**: consists of a mixture of sand, aluminium and a unique type of adhesive, used instead of plain sand for extreme slippery rail conditions.
- **Schnabel car**: A specialized type of freight car for extra heavy and over sized loads; the car is loaded in such a way that the load forms part of the car superstructure.
- **Searchlight**: A signal with a single light source usually capable of displaying three different colors. An internal mechanism governs the color displayed.
- **Section**: The division of the track for security (occupation).
- **Semaphore**: A type of signal that has a moving arm; any signalling using semaphores.
- **Shay**: A type of geared steam locomotive built to the patents of Ephraim Shay.
- **Shoofly** (US): A temporary stretch of track that takes trains around construction or an accident scene.
- **Shunt** (UK) (AUS): To move trains or vehicles from one track to another.
- **Shunt** (US): To bond the rails/power feeds between sections on trolley/light rail systems, so as to temporarily bridge past dead areas.
- **Shunter** (UK): switcher (US) or shifter (PRR only): A small locomotive used for assembling

Points of Interest

British lower-quadrant **semaphore** stop signal (absolute) with subsidiary arm (permissive) below

Two-head color position **signal** on CSXT mainline at Savage, Maryland. The left head displays "Stop", the right head, "Clear".

trains and moving railroad cars around. Also, a person involved in such work.

- **Shuttle service**: A train, usually a passenger service, that runs back and forth over a relatively short distance, such as between a junction station and a branch-line terminus.
- **Side tank**: A tank locomotive with water tanks mounted each side of the boiler.
- **Siding**: A section of track off the main line. Sidings are often used for storing rolling stock or freight. A siding is also used as a form of rail access for warehouses and other businesses, where the siding will often meet up with loading docks at rail car height in the building. In the U.S. the term is also used to cover the British term: **loop**. Also, a passing track in the U.S.
- **Signal**: A device that indicates to the driver of a train information about the line ahead.
- **Signal aspect**: The information conveyed to a railroad vehicle operator by a block signal. Signals may use colored lights, position-significant lights or mechanical semaphores to generate various aspects.
- **Signal box**: A building or room which houses signal levers (usually in a frame), a control panel or a VDU-based control system.
- **Signal Passed At Danger** or **SPAD** (UK): where a train disobeys a stop signal.
- **Signalman**: A person in charge of the signalling at a station or junction, often in a Signal-box.
- **Six-foot**: The narrow corridor between a pair of closely-spaced tracks, nominally six feet wide.
- **Slack** (UK): A temporary speed restriction to protect, for example, sections of track in poor condition and awaiting repair. Also applies to the timing tolerance included in timetable schedules to allow for such restrictions.
- **Slack action** (UK/US): Looseness in a train caused by mating clearances in couplers.
- **Sleeper** (UK), tie (US): Bars placed at 90° to the rail tracks to support the rails. Generally of wood, concrete or steel, with hardware to affix the rails, usually spikes, nails or bolts. Note in the UK baseplates and clips are used to affix the rail to the sleeper. Spikes are widely used in North America.
- **Slippery rail**: The condition of fallen leaves or

CNR prairie rail snow plough

A privately-owned **speeder** on display at the Mad City Model Railroad Show and Sale in Madison, Wisconsin, February 2004

Two unused and one heavily corroded **spikes**. The measurement scale shown is inches.

Jordan Spreader

A pair of EMD SW900 **switchers**

other debris lying on and clinging to a railroad track that could cause train wheel slippage, resulting in premature wheel wear and train delays.

- **Slow order**: A local speed restriction below the track's normal speed limit often designated by yellow and green flags. Slow orders can be imposed on a temporary basis to protect, for example, maintenance of way employees while sections of track are under repair. Widely used in areas where track is substandard and in need of repair.
- **Slug**: A locomotive that contains traction motors yet lacks the diesel engine to create its own power, which is instead supplied by a connected 'mother' locomotive.
- **Smokebox**: An enclosed (normally cylindrical) space attached to the end of the boiler opposite the firebox on a steam locomotive (normally the front). Supports the stack/chimney; steam pipes to and from the cylinders pass through here; contains the blastpipe/exhaust nozzle where the exhaust steam is used to provide draft for the fire. In superheated locomotives, also contains the superheater header and (optionally) a front-end throttle. A smokebox door allows access for cleaning.
- **Smokestack** (abbr. **stack**) (US): chimney (UK).
- **Snow plough** (Snowplow) or rail snow plough is a rail service vehicle used for snow removal from train tracks.
- **SPAD** (UK): Signal Passed At Danger, where a train disobeys a stop signal. Sometimes referred to as a "blown red" in U.S. railroad slang.
- **Speeder** (US): A small vehicle used to let track inspectors and work crews move quickly to and from work sites. (Obsolete) Speeders have mostly been replaced by trucks and SUVs with retractable flanged wheels.
- **Spike**: A bolt, pin or nail used to hold rails, or plates connected to the rails (known as tie plates), to sleepers (ties). Commonly called a "Dog" or "Dogspike" in Australia.
- **Spreader** a maintenance of way equipment designed to spread or shape ballast profiles, remove snow, clean and dig ditches as well as

trim embankments

- **SPT** (UK): Signal-post telephone - A direct no-dial telephone link to the relevant Signal-box, positioned on or near a signal.
- **Spur** (US): A stretch of rail that branches off the main line. Different from a siding or stub, spurs can be miles in length, and usually have only one destination at the end.
- **SPURT** (India): An acronym for Self Propelled Ultrasonic Rail Testing, a self-propelled rail defect detector car.
- **Staff and ticket**: A method of safeworking involving a token.
- **Standard gauge**: Railroad track where the rails are spaced 1,435 mm (4 ft 8 ½ in) apart. This is by far the most common gauge of railway worldwide.
- **Station-master**: The person in charge of a station.
- **Station pilot** (UK): Shunting engine based at a major passenger station and used for passenger train shunting duties.
- **Steam generator**: A device generally used in passenger trains to create steam for heating. The steam generator is usually in the locomotive but may also be located in other cars.
- **Steam reverser**: A Cut Off worked by a steam piston controlled from the cab.
- **Steeplecab** (US): An electric locomotive with a central cab and sloping "noses" on each end.
- **Steward**: A person in a dining car with a role similar to that of a Maitre d'Hotel.
- **Stub** (North America) A relatively short section of track that ends at a bumper or wheelstop, most often found in a terminal. Not to be confused with a spur, which may be miles (kilometers) in length.
- **Subway** (UK): A tunnel passing underneath the railway tracks to allow passengers to cross from one platform to another.
- **Subway** (US): A railroad that runs underground, generally in a large city. Subways are also considered "heavy rail" because they operate on their own dedicated track. Not to be confused with the interurban definition of subway, which is normally a light-rail passenger service running mostly underground.
- **Supercharger** A mechanical device that boosts

the pressure of engine intake air to above atmospheric level, causing an increase in power. Not to be confused with the blower used to scavenge the cylinders of a naturally aspirated two-stroke Diesel engine.
- **Superelevation** (UK): Synonymous with **cant**: the banking of railroad track on curves. Specifically, the practice on high speed lines (where the cant needs to be higher) of gently introducing the elevation of the outer rail before the bend starts, in order to avoid sudden lurches.
- **Superheater**: A device in a steam locomotive that raises the temperature of saturated steam substantially beyond the boiling point of water, increasing power and efficiency.
- **Switch** (US): points (UK). Also "turnout".
- **Switcher** (US), shunter (UK): A small locomotive used for assembling trains and moving railroad cars around.
- **Switchman**: A railroad worker responsible for assembling trains and switching railroad cars in a yard; now often used together with brakeman as a single job description ("brakeman/switchman").

T

Definitions

- **Tank car**: A type of rolling stock designed to transport liquid and gaseous commodities.
- **Tank engine** (UK): A locomotive that carries its own fuel and water instead of hauling a tender. The fuel is usually in a bunker behind the cab and the water in tanks on either side of, above, or below the boiler (respectively: side tank, saddle tank, well tank).
- **Team track**: A spur or siding for loading freight, often used by firms not having their own direct rail access.
- **Ten-foot**: An area, usually at least ten feet wide, between a pair of widely-spaced tracks, wide enough to form a place of safety in which railway workers can stand while a train goes past.
- **Ten-wheeler** (US): A steam locomotive with a 4-6-0 wheel arrangement.
- **Terminal station** (esp. U.S.), **terminus** (esp. UK): A station sited where a railway line or service ends or terminates.

Points of Interest

A Finnish **ten-wheeler**

- **Terminal railroad** (or **terminal railway**) is company in the United States that owns no cars of its own and transports only the railroad cars of other companies around a specific terminal station.
- **The T** (US): A nickname for Massachusetts Bay Transportation Authority (MBTA) the Subway service through Boston, Massachusetts.
- **Theatre indicator** (UK) An illuminated number usually attached to signal indicating arrival platform for train approaching a station.
- **Third Rail**: An electrified rail that runs along the tracks, giving power to trains. Used mostly in subways and rapid transit systems.
- **Through platform**: The standard platform and track arrangement at a station. The train pulls alongside the platform, arriving from one end of the station, and may pass out the other end of the station by continuing along the same track.
- **Through-routing**: Combining two or more different railways onto a common length of track. This is often done to eliminate redundant trackage and/or improve service.
- **Tie** (US): sleeper (UK): A rectangular object used as a base for railroad tracks.
- **Tram**: A city-based rail system that typically shares its operational space with other vehicles and often runs on, across or down the center of city streets.
- **Tram-train** are **trams** that are designed to run both on the tracks of a city-based rail system and on the existing railway networks. Tram-trains dual-voltage capability makes it possible to operate at lower speeds on city streets and at over 60 mph (100 km/h) on main line tracks allowing travel in an extended geographical area without changing the method of transport.
- **Tie plate**: A plate which is bolted to sleepers, holding the rails in place.
- **TOFC**: An abbreviation for "Trailer-On-Flat-Car" (Intermodal freight transport).
- **Token**: A physical object given to a locomotive driver to authorize him to use a particular stretch of single track.
- **Top and tail** (UK): A train with locomotives at both ends, for ease of changing direction.
- **Torpedo** (US): A small explosive device strapped to the top of the rail to alert an approaching train of danger ahead. A torpedo creates a loud noise upon contact with a locomotive wheel, signaling the engineer to reduce

speed to 20 mph or less; the train cannot resume its original speed until it has traveled at least a mile beyond where it encountered the device. Traditionally used in pairs to ensure that the sound registered with train crews, torpedoes today are essentially obsolete as modern locomotive cabs' soundproof construction renders the devices useless. (**UK**:Detonator)

- **Torpedo tube**: A slang term for a type of roof-mounted air reservoir. The long, cylindrical tanks (which resembled the torpedo launch tubes on World War II PT boats) were integral to the design of the EMD SD24, and retrofitted (both at the factory and on an aftermarket basis) to other locomotives such as the GP7, GP9, and CF7 (typically when the units were placed into passenger train service and larger fuel and water storage tanks were required).
- **Trackage rights** (US): The legal right of one railroad company to use the tracks of another, as agreed to by the companies concerned or their predecessors; may also be ordered by government regulators, for example, as a condition of a merger. **Running powers** (UK).
- **Track bed** or **trackbed**: the foundation of rail tracks
- **Track circuit**: An electrical device for proving that a section of track is clear of vehicles, and used in the signalling logic.
- **Trackside objects**: Wayobjects under "W" below.
- **Track bulletin**: A form used by railroad employees that shows the locations of slow orders, maintenance of way work locations, and other conditions affecting the track and movement of trains.
- **Track tamping machine**: Generally, a locomotive used in track maintenance and equipped with track lifting facilities, and paddles enabling ballast to be pushed beneath a rail track so as to assure its level and cant.
- **Track transition curve**: The gradual application of superelevation and tighter curve radius, calculated with reference to the anticipated line speed and the final curve radius, on the approach to a bend. Also known as the *transition spiral* and *spiral easement*.
- **Track warrant (TWC)** (US) **Occupancy Control System (OCS)** (CA): A system for authorizing main track occupancy using defined points such as mileposts, switches, or stations.
- **Traction motor**: A large electric motor which drives the wheels on a Diesel Electric Locomotive. The number of traction motors depends on the locomotives

configuration and horsepower. Most have direct drive axles and some have gear driven axles.

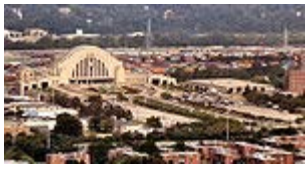
- **Traction supply**: The supply for the driving traction motors of electric trains.
- **Tractive effort**: the pulling force exerted, by a locomotive or other vehicle.
- **Trailing**: A turnout is trailing if the two legs of that turnout merge in the direction of travel.
- **Trainee**: An employee that is new on the job and has gotten out of railroad school.
- **Trainman**: An employee assigned to train service, such as a Conductor, Brakeman or Switchman.
- **Trainmaster**: A Dispatcher, the person(s) in charge of all traffic within the assigned blocks.
- **Train order**: A system for authorizing main track occupancy using telephone, telegraph and wayside stations to pass authority to train crews.
- **Train register** (UK): A book or loose-leaf sheets kept in a signal box and used to record the passage of trains, messages passed, and other prescribed events.
- **Trainset**: A group of rolling stock that is permanently or semi-permanently coupled together to form a unified set of equipment. Trainsets are most often used in passenger train configurations.
- **Treadle**: A mechanical or electrical device for detecting the presence of a rail vehicle with a pin-point accuracy, unlike a track circuit which can be detection over a length of up to several kilometres.
- **Triangle** (UK), **Wye** (US): A track layout that facilitates the turning of engines or complete trains.
- **Truck** (mainly US and Canada as well as Mexico)
- **Truck** (UK, outdated/informal): freight car.
- **Turnout**: A switch (also known as a set of points)
- **Turntable**: A section of track that can rotate, allowing rolling stock to be reversed, and also allow a large number of engine maintenance sidings to be accessed in a small area.

U

Definitions

- **Underbridge** (UK): A bridge carrying the railway and allowing a roadway (etc.) to pass under the railway.
- **Union station** or **union terminal** (US), **joint station** (UK): A railway station (q.v.) at which tracks and

Points of Interest



facilities are shared by two or more railway companies.

- **Up** (UK, etc.): A direction (usually towards London, other capital city, or the headquarters of the railway concerned) or side (on left-running railways, the left side when facing in the up direction). The opposite of **down**. The up direction is usually associated with even-numbered trains and signals.
- **UP** (US): The common name and reporting mark for the Union Pacific Railroad.

The main concourse building and facade of **Cincinnati Union Terminal**

V

Definitions

- **Vacuum brake** A continuous train brake which is fail-safe in operation: the brake is powered by a vacuum from the locomotive but the application is actually by atmospheric pressure when the vacuum is released. Now largely superseded by the air brake.
- **(goods) Van** (UK), boxcar (US): An enclosed railroad car, or piece of rolling stock, used to transport freight.
- **Van** (CA): Eastern Canadian word for caboose.

Points of Interest

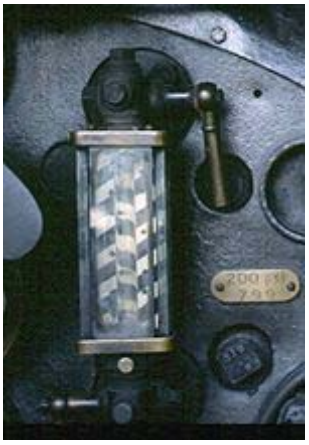
A **Boxcar** (US) **Goods van** (UK): rolling stock, used to transport freight

W

Definitions

- **Water glass/gauge**: A device showing the level of water in the boiler.
- **Way car**: A term used by the Chicago, Burlington and Quincy Railroad, Chicago and North Western Railway and Atchison, Topeka and Santa Fe Railway instead of ***caboose***.
- **Wayobjects** or **Wayside objects**: Trackside objects are any structures at the wayside or beside the rail tracks usually within the right-of-way, such as:
  - railway signals
  - third rails
  - overhead lines and their supports
  - electrification systems
  - platforms
  - boom barriers
- **Wayside**: Trackside. The term presumably has its origin from the term right-of-way.
- **Well tank**: A type of tank locomotive. The water tank is

Points of Interest



Water gauge. Here the water is at the "top nut", the maximum working level.

mounted between the frame plates, beneath the cab and boiler.

- **Well wagon**: A flat wagon that has a depressed centre and is used for carrying extra tall loads.
    - Well car.
    - Aircraft parts flatcar.
- **Wheel**: The rolling component typically pressed onto an axle and mounted on a rail car or locomotive truck or bogie. Wheels are cast or forged (wrought) and are heat treated to have a specific hardness. New wheels are trued to a specific profile before being pressed onto an axle. All wheel profiles need to be periodically monitored to insure proper wheel to rail interface. Improperly trued wheels increase rolling resistance, reduce energy efficiency and may create unsafe operation. A railroad wheel typically consists of two main parts: the wheel itself, and the tire around the outside. A rail tire is itself steel, and is typically heated and pressed onto the wheel, where it remains firmly as it shrinks and cools.
- **Wheel Climb**: The process of a wheel climbing up and often off the inside or gauge side of the rail. It is a major source of derailments. Wheel climb is more likely to occur in curves with wheels whose flanges are worn or have improper angles.
- **Wheel Flange**: The inner section of a wheel that rides between the two rails. The angle between the wheel tread and flange is often specific to the rail to prevent wheel climb and possible derailments. The wheel flange is part of the wheel tire.
- **Wheel slip**: The loss of traction due to a slippery rail or wheel. Wheel slip was common with steam engines as they started to move due to the excessive torque often generated at low speed. Steam engines carried sand dispensing gear to increase traction at the start of motion.
- **Wheel Tapper**: An historical railway occupation; people employed to tap train wheels with hammers and listen to the sound made to determine the integrity of the wheel; cracked wheels, like cracked bells, do not sound the same as their intact counterparts. The job was associated with the steam age, but they still operate in some eastern European countries. Modern planned maintenance procedures have mostly obviated the need for the wheel-tapper.
- **Wheel Tread**: The slightly conical section (often with a 1 in 20 slope) of a railroad wheel that is the primary contact point with the rail.

A wheel tapper at work on the Bulgarian railway

A double **Whistle post** located on the Grand Trunk Western Railroad

Satellite image of a **wye** where two approaches to the interchange have been abandoned

- **Whistle**: Train whistles are used as a safety warning and also by the engineer to communicate to other railroad workers. Also a *nickname* for an air horn on a diesel locomotive. Steam engine whistles were historically known as chimes in the US during the 19th century.
- **Whistle post**: An advanced warning to the engineer of an upcoming grade crossing. It is the point at which the engineer should begin sounding the whistle or horn.
- **Whyte notation**: A system of describing steam locomotive wheel arrangements, e.g. 4-6-4, 2-10-2. The first number indicates the number of "pilot" wheels that help lead the engine into turns. The second is the number of coupled wheels ("drivers"). Third are the trailing idler wheels, usually to provide support to larger fireboxes. Articulated locomotives are similarly described. For example, a Union Pacific "Big Boy" would be described as a 4-8-8-4, wherein the pilot has four wheels, followed by two sets of drivers, 8 wheels per set, and a 4 wheel trailing bogie under the firebox. The numbers include the wheels on both sides of the engine, so a 2-8-2 engine would have one idler, four drivers, and a final idler on each side of the engine.
- **Wigwag**: A Level or Grade Crossing Warning Signal consisting of a swinging disc facing road traffic with a red light in the centre. The disc normally hangs straight down, but an approaching train will set it swinging from side to side, the red light will illuminate or flash and a bell will ring.
- **Wrong-side failure**: A failure in a signalling system that leaves the system in a dangerous condition.
- **Wye (US)**, **triangle** (UK): Three railroad tracks in a triangular form with switches at all three corners. With sufficient lengths of track leading away in all three directions, a wye can turn a train of any length.

X

Definitions

- **X-ing** (AU): Slang for road crossing or level crossing. Crossing (US).

Points of Interest

A Railroad Crossing (**X-ing**) sign in Belton, Missouri

Y

Definitions

- **Yard**: A location where rolling stock is switched to and from trains, freight is loaded or unloaded, and consist made up. Also Classification Yard or Hump Yard.
- **Yardmaster**: The person(s) responsible for conducting all traffic within the yard. The Yardmaster gives orders for which cars go where in order to assemble or disassemble a consist.
- **Yellow**: A colour associated with a warning or a need to slow down when used by flags or signals; the exact meaning varies from railway system to railway.

Points of Interest

A railroad **yard** in Chicago, Illinois, (Proviso Yard) operated by the Chicago and North Western Railway as seen in December 1942

Z

Definitions

- **Zig zag**, (U.S. commonly) **switchback**: a way of climbing hills,

Points of Interest

where the train reverses direction for a while, and then reverses again to continue its journey.