Design Details of Railways, Railroads and Metros

Introduction

There are many parts of the railway business which are interesting in their own right and which questions are asked about from time to time. This page looks at detailed parts of equipment, systems, standards, dimensions, procedures and infrastructure in no particular order. New items will be added from time to time.

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Deadman

During the last decade of the 19th century, trains powered by electricity began to appear. Since there was no fire for a fireman to attend, it was logical that only one man was needed in the cab. However, it was thought that there should be some way of ensuring he always kept alert and, indeed, that he always stayed in the cab while the train was running. It therefore became usual to provide some sort of vigilance device.

The vigilance device was originally installed to cover the situation where a driver collapsed due to illness whilst in charge of a train and it usually consisted of a spring loaded power controller handle or button. It therefore quickly became known as the "deadman's handle". More recently it has become known as a vigilance device or "driver's safety device" (DSD). In France it is called "VACMA", short for "Veille Automatique de Contôle à Maintien d' Appui".

There are three types of deadman devices; a spring loaded master controller handle, a spring loaded pedal or an "alerter". The deadman's handle usually requires constant pressure to maintain operation. If the handle is released, the brakes will apply. The pedal requires operation at regular intervals. One minute seems to be the normal time allowed between pedal depressions. An audible "warble" warns the driver that he must depress the pedal within 3 seconds. For an "alerter", the key thing is positive movement of the controls: if you don't move something occasionally, the alerter will come on and you have to acknowledge it. If not, it will cause a penalty brake application. This is the popular system in the US. In some countries, a push button is provided in place of the alerter system.

French railways used to favour a ring fitted round the controller handle. You have to grip the ring and lift it against spring pressure to keep the brakes off. There is a time delay, essential as most of the driving positions are in the centre of the cab away from the side windows. Of course, you need to look out of the side window sometimes for shunting, coupling and so on. It's not much good if you can't hold on to the "deadman" and there's no time delay.

Couplers

In order for two railway vehicles to be connected together in a train they are provided with couplers. Since there are a large number of railway vehicles which might have to be coupled at one time or another in their lives, it would seem sensible to ensure that the couplers are compatible and are at a standard position on each end of each vehicle. Of course, life isn't as simple as that, so there are a variety of different couplers around. However, there is a high degree of standardisation and some common types have appeared around the world.

Link and Pin

The simplest type of coupler is a link and pin. Each vehicle has a bar attached to the centre of the headstock (the beam across the end of the vehicle, variously called the end sill or pilot in the US) which has a loop with a centre hole attached to it. Each coupler has a bellmouth around the end of the bar to assist in guiding the bar with the hole into place. The loops are lined up and a pin dropped into them. It's not very sophisticated but it was used for many railways during the 19th century and has persisted on a few remote lines to this day. There were some variations on the idea and here is a good description with photos and drawings

Bar

The next type of coupler is the bar coupler. This is what is known as a semi permanent coupler. It cannot be disconnected unless the train is in a workshop and access underneath the train is available. It is normally used in EMUs which are kept in fixed formations of two, three or four cars. The bar couplers are located within the unit, while the outer ends of the unit have some type of easily disconnected coupler. Bar couplers are simple, just consisting of a bar with a hole at the inner ends through which the car body is connected by a bolt. Others consist of two halves which are just bolted together as shown in this example:

3-Link Coupling:

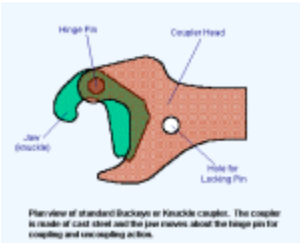
This type of coupling is exactly what it says - a set of three links which are hung from hooks on each vehicle. A development of this is the "Instanter" coupler, which has a middle link forged into a triangular shape to allow the distance between vehicles to be (crudely) adjusted. This is to allow the side buffers used with the coupler to be adjacent to each other and provide some degree of slack cushioning.

The coupler required a person to get down on the track between the two vehicles and lift the coupling chain over the hook of the other vehicle. Sometimes a "coupling pole" was used for quickly uncoupling freight wagons.

This photo shows a screw coupler in the uncoupled position. This is a development of the 3-link coupling where the middle link is replaced by a screw. The screw is used to tighten the coupling between the two vehicles so as to provide for cushioning by compressing the side buffers. The following photos show typical screw couplings.

 The photo on the left shows a coupled screw coupler also showing typical fittings of passenger vehicle coupling In addition to the mechanical couplings required to connect the vehicles, trains had to have through connections for brakes, lighting and heating. In this photo, the arrangements for coupling two passenger coaches in a steam hauled train are shown. Note that this particular type of coach was provided with safety chains, which were fitted in case the main coupling broke. Of course, all the work involved in connecting the two vehicles was carried out manually. It is hard work and sometimes dangerous. It is still common in the UK and Europe.

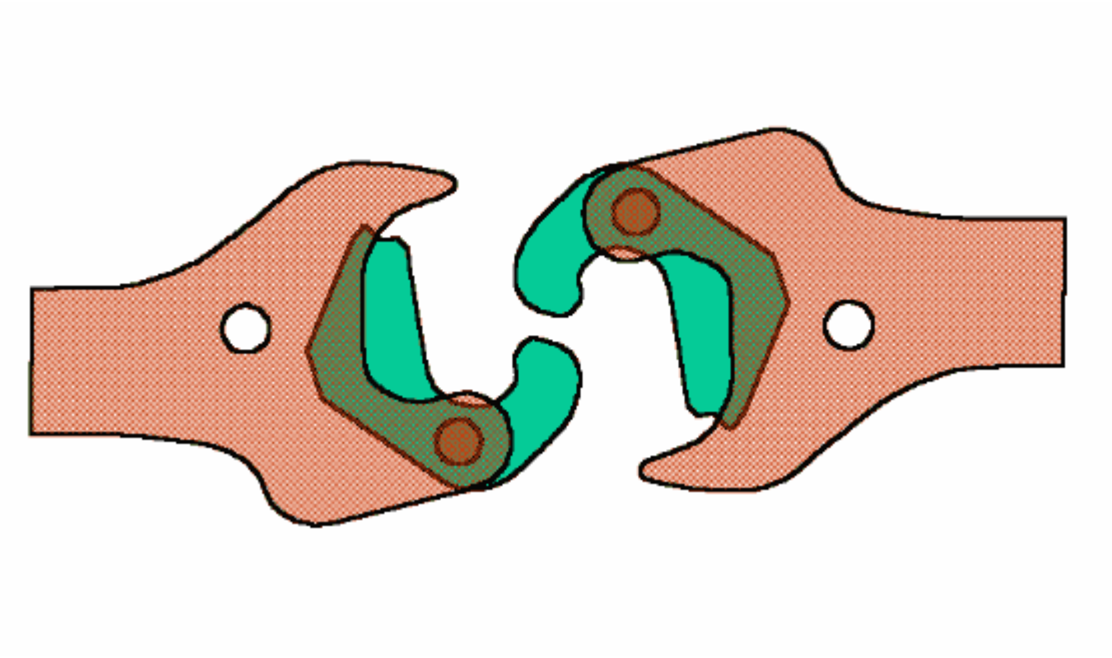
Buckeye Coupler



By far the most common coupler seen around the world is known variously as the "Knuckle", "Buckeye" or "Janney" coupler, diagram left. This is an automatic, mechanical coupler of a design originating in the US and commonly used in other countries for both freight and passenger vehicles. It is standard on UK hauled passenger vehicles and on the more modern freight wagons. The term "Buckeye" comes from the nickname of the US state of Ohio "the Buckeye state" and the Ohio Brass Co. which originally marketed the coupler. It was invented in 1879 by a US civil war veteran named Eli Janney, who wanted to find a replacement for the link and pin couplers then standard in the US. Link and pin coupler required staff to stand between cars to couple and uncouple and there were many injuries and even deaths as a result. Janney's invention solved these problems and was taken up by a number of lines. The device eventually became standard when the link and pin coupler was banned by the US government in 1900.

The coupler (shown above) is made of cast steel and consists of four main parts. The head itself, the jaw or knuckle, the hinge pin, about which the knuckle rotates during the coupling or uncoupling process and a locking pin. The locking pin is lifted to release the knuckle. It does this by raising a steel block inside the coupler head which frees the knuckle and allows it to rotate.

The simplified animated diagram below shows the steps when two couplers are being coupled.



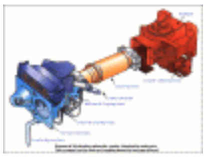
To couple two vehicles, the knuckles must be open. When the two vehicles are pushed together, the knuckles of the two couplers close on each other and are locked from behind by a vertical pin dropping a steel block into place behind a raised casting on the knuckle. To uncouple, one of the pins must be pulled up to release the block locking the knuckle. This is done by operating a lever or chain from the side of the vehicle.

Fully Automatic Couplers

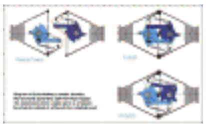
More and more railways are using fully automatic couplers. A fully automatic coupler connects the vehicles mechanically, electrically and pneumatically, normally by pushing the two vehicles together and then operating a button or foot pedal in the cab to complete the operation. Uncoupling is done by another button or pedal to disconnect the electrical contact and pneumatic connection and disengaging the coupler mechanically.

Fully automatic couplers are complex and need a lot of maintenance care and attention. They need to be used often to keep them in good working order. There are a number of different designs in use. Two are shown here. Click on the images to enlarge and read the descriptions.

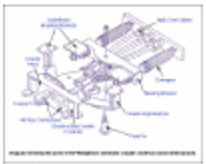
The Scharfenberg automatic coupler is a design widely used on European multiple unit rolling stock of all types, ranging from high speed trains to light rail vehicles. The coupler has a mechanical portion with pneumatic and electrical connections. The units are coupled by pushing one onto the other. The electrical contacts mounted under the mechanical coupler are protected by a cover when uncoupled.



A drawing of another version of the Scharfenberg coupler which has the electric contacts over the coupler. The part names are included in this drawing.



A drawing of the mechanical portion of the Scharfenberg coupler showing how the two couplers engage and uncouple.



London Underground uses a type of automatic coupler known as the Wedgelock. It was first introduced in 1935 and has remained little changed since. It provides full mechanical, electrical and pneumatic connections. Older versions were fully automatic, being released from a pushbutton in the driver's cab. More recent versions use a hand operated release which has to be operated in each cab. A version of the coupler is also used on the Glasgow Subway.

Doors

There is an array of doors in use on rolling stock today. Plug doors, bi-folding doors, slam doors, sliding pocket doors and exterior sliding doors immediately come to mind.

Plug doors are usually found on Light Rail Vehicles (LRVs) but can often be found on heavy rail rolling stock too. These doors are bi-parting, i.e. two leaves open from the middle. When they are opened, the doors 'pop' forward and then swing on a fulcrum arrangement to open out onto the exterior of the vehicle. When the command to close is received, the reverse operation takes place and the doors 'pull' inwards to line up snugly with the side of the bodyshell. There is a rubber edging strip around the doors which forms a seal when in the closed position. This type of door is a maintenance headache with all the moving parts and occasionally unreliable rubber edges. However, it does provide a tight seal and a flush exterior finish which looks good and is easy to clean when passing the vehicle through a car washing machine.

Bi-folding doors are commonest on LRVs and consist of two panels per side of the opening. Some European coaches have bi-folding doors opening one way only. The doors are electrically controlled, either by the driver or by passengers (with a push button). When the command to open is received, the doors fold inwards and the panels will end up parallel to the step well or windscreen. The problem with these doors is that if the train is full of commuters as the panels swing in they can hit a person standing in this area. They are also very difficult to seal requiring clearance on the underside for the opening motion, which allows the ingress of water either in operation or when passing through the train wash.

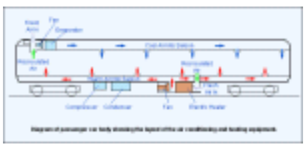
Sliding pocket doors are found on all types of rolling stock and, as the name implies, on opening slide into a pocket between the inside of the bodyshell and the interior lining. The lining in this area will usually protrude into the interior to accommodate the door panel. The door panel can be bi-parting or a single leaf. The door operator can be over the doorway or mounted on the floor behind a suitably positioned seat. The maintenance headaches occur particularly with the runner provided along the bottom of the opening to guide the runner for the panels. This becomes blocked with dirt over time causing the doors to jam.

Another type of door is the exterior sliding door or outside hung door and, again, is found on a number of different types of rolling stock. It is a very popular type of door because it is easier to design but most designs suffer from poor aesthetics due to the very visible runner that is on the exterior or the bodyshell for the door(s) to open and close along. Some types of these doors simply slide backwards and forwards on the runners for the opening and closing motion. Usually at the command of the train driver or sometimes at the behest of the passenger. More sophisticated types work in a similar manner to the plug door, first 'popping' out before sliding back on the runner, similarly on the closing cycle 'pulling' back in to the car shell opening.

Slam doors were the standard used for years on British Railways rolling stock but have now been 'outlawed' by the UK Health and Safety Executive and all stock still in service with this type of door must be replaced by 2002. Personally, I do not think this will happen. There are too many of these old vehicles left. The slam door is the traditionally functional, swinging, hinged door that opens manually by the turn of a handle. What more can be said about them?

Air Conditioning

Most modern passenger vehicles are provided with air conditioning and they will also have heaters in countries where the climate gets cold enough to require it. Here is the basic layout of an air conditioned coach, also equipped with heating equipment.



The air conditioner is designed to the so-called "split" arrangement, where the condenser and compressor are mounted under the car floor and the evaporator and fans are mounted in the roof. Sometimes there are two sets in the roof. The coolant from the condenser is passed to the evaporator in the roof through a connecting pipe. On older cars of the New York Subway, these connecting pipes doubled as handrails in the passenger area. They were so cold to touch, you almost got frostbite if you held on to them for too long.

The heater is a separate unit under the car floor, consisting of an electric resistance heater and a fan.

Hot air is blown into the car by the fan, having passed through the heater from and underfloor intake. This intake collects some fresh air and uses some recirculating air from inside the car. The same air intake arrangement is provided in the roof for the air conditioning fan in the roof.

Some car heaters on EMU trains use resistance grids heated by the dynamic braking system. Waste energy generated by braking is converted into electric energy by the traction motors and this is fed into the heater grids.

Escalator Steps

Escalators are common in public buildings and railway stations. However, their uses can be quite different in terms of volume and speed. Most escalators seen in stores and office buildings are fairly lightly used and slow speed. This example of a small lightweight escalator as installed at Stratford station, London but those used in railway stations need to be faster and heavier in construction because of the greater volumes of people which use them.

One visible feature of transportation escalators is that more flat steps should provided at the landings - four instead of two, as shown in the photo, left.

The reason for having the larger number of flat steps is to allow people to board and alight from the escalator more quickly. A two-step escalator will cause people to be more cautions because the steps start to rise immediately the passenger boards. A four-step escalator allows people more time to adjust to the movement, so the machine can be run faster and provide increased capacity.

Escalator Locations

Escalators must be positioned carefully. On high capacity railways, they are important for clearing platforms quickly at peak times when a lot of passengers have arrived on a train and the platform needs to be clear for the next train. Ascending and descending passengers need to be separated and barriers are often provided to help this.

Suicide Pits

 A feature of London's underground tube lines is that stations are provided with suicide pits. In London, there were so many suicides during the early 1930s, that all the deep level tube line stations were fitted with pits between the rails to facilitate removal of the bodies or rescue of the survivors. In recent times, there have been between 100 and 150 suicides on the system each year. This is two or three a week. For some strange reason, the Jubilee Line extension also has suicide pits even though the stations are equipped with platform edge doors.