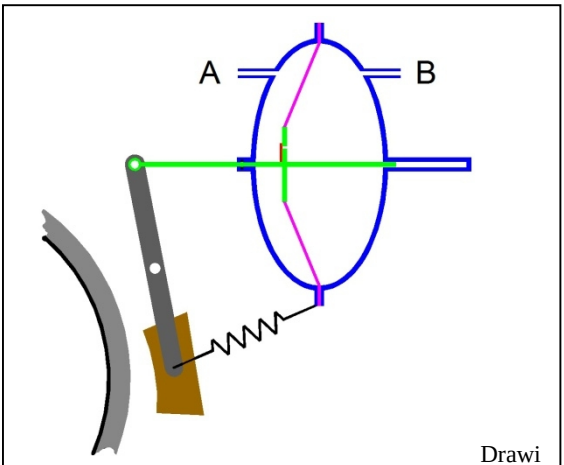
An Introduction to Vacuum Braking

From articles written by Paul Konig for the Pinewood (Wokingham) Miniature Railway Society newsletters.

The majority of locos used on the Pinewood railway have used mechanical braking systems, both on the loco and the driving trolley / tender, to bring a train to a halt as and when required. With the requirement to run longer trains, for example the six carriage trains at our Santa Specials, the effectiveness of these systems can be reduced as the weight of all the passengers and coaches becomes many times heavier than the loco and its driver. Vacuum brakes are therefore being developed for the Pinewood passenger carrying stock to mitigate this problem by applying brakes on all the carriage wheels.

Principles of operation

A vacuum braking system comprises a method of evacuating the air from a pipe running the length of the train, the 'train pipe' (either using a steam locomotive's "ejector" or an electrically driven vacuum pump) to create a vacuum, and a method of destroying this vacuum. The brake system is arranged so that when the vacuum is created the brakes are pulled off; but when it is destroyed the brakes are applied. This has the advantage of being fail-safe, i.e. in the unlikely event that a pipe was to break (for example, if a passenger coach became detached from the loco) the air introduced to the coaches brake system would destroy the vacuum applying the coach's brake automatically and bringing the coach to a controlled stop.



Drawing by Colin Gross

Sketch of a vacuum brake system.

This picture may help you understand how vacuum braking works, but please remember that in the "real world" the components will be properly engineered. For example the "small rubber flap" described below would more likely be a nicely built one-way valve rather than a bit of rubber covering a hole

In the drawing, part of the carriage wheel is shown at the bottom left. A brake block (coloured brown) is connected by the lever arm to the brake cylinder piston

and piston rod (bright green). A weak spring is used to pull the brake block away from the wheel, which also moves the piston to the left hand side of the vacuum brake cylinder (coloured blue). Inside the cylinder is a rubber diaphragm (pink) that seals the piston to the cylinder, dividing the cylinder into two halves. The final component (that is rather hard to see) is a small rubber flap (coloured red) that is on the left hand side of the piston. This small rubber flap covers a small hole in the piston. The pipe (A) from the cylinder is connected to the locos ejector (or vacuum pump), via the "train pipe" while the pipe (B) goes to a large tank that acts as a vacuum reservoir.

If you start sucking the air out of the system via pipe (A) the small rubber flap will be sucked away from the piston and you will then also suck the air out of the vacuum reservoir. This will take quite a lot of sucking as there is a lot of air to remove. By convention the amount of vacuum you create is measured in Inches of Mercury, and most miniature railway vacuum braking systems are built so that 15 inches of vacuum will pull the brakes off. So for safety you will keep sucking until you have achieved about 20 inches of vacuum in the train pipe, both sides of the brake cylinder, and in the vacuum reservoir. When you stop sucking the "pressure" of the vacuum will be the same on both sides of the piston, so the weak spring will hold the brake in the off position and the small rubber flap will "spring" back to cover the hole in the piston.

If you now let air into the train pipe the pressure of the air will be greater than the pressure of the vacuum (normal air pressure corresponds to zero inches of Mercury) so the small rubber flap will be pushed firmly against the piston to seal the hole and the piston will be pushed by the air pressure towards the right of the cylinder. This will apply the carriage brake to the wheel.

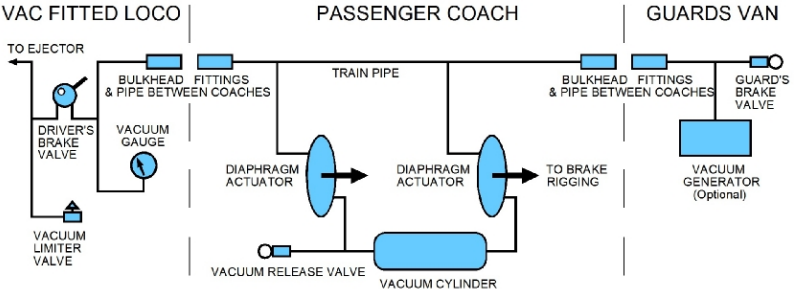
When you want to release the brake again you will only need to suck the air out from the train pipe and the left hand side of the piston until you reach the same level of vacuum as remains in the vacuum cylinder connected to pipe (B), at which point the weak spring will pull the piston back to the left and release the brakes.

You can see that if the carriage becomes detached from the loco (or other carriages) the air will get in via pipe (A) and automatically apply the brakes on the detached carriage, and similarly the brakes will also be applied to all the remaining carriages attached to the loco. The brake system is "fail-safe".

The only remaining problem is that if you want to remove a carriage from the train its brakes would be stuck on and you could not move the carriage. To overcome this, the vacuum reservoir will have a plug (vacuum relief valve) fitted that can be removed to destroy the vacuum in the reservoir and thus via pipe (B) on the right hand side of the piston. With the pressure on both sides of the piston being equal again (at normal air pressure) the weak spring can once again release the brakes.

Pinewood's vacuum brake system

The schematic drawing on the next page shows the vacuum braking system being developed for our new passenger stock. It is also being retrofitted on all the existing coaches fitted with the 'standard' bogie design.



Drawing by Paul Konig & Colin Gross

Schematic drawing of the Pinewood Vacuum Braking System.

Where the existing coach bogies preclude the fitting of vacuum brakes, the carriages will be "piped through" to maximise the flexibility of rake formation. The main vacuum pipe running through the system is referred to as the 'train pipe'.

Passenger coach equipment

Both bogies on the coach are fitted with diaphragms and brake rigging to maximise the braking force and reduce the risk of the wheels locking up under braking. A central vacuum reservoir, to reduce the impact of small leaks on the overall braking system is installed, as is a vacuum relief valve, which allows the coaches to be used when the vacuum systems are not in operation. Proprietary equipment from PNP Railways is used wherever possible.

Photo Paul Konig

A brake diaphragm and linkage fitted to a coach bogie.

Loco equipment

If the loco is fitted with a vacuum ejector (typically steam locos), this is operated to draw air out of the system to create, and maintain, the vacuum at about 15 inches. The loco will typically be fitted with a vacuum pressure gauge and brake control valve.

Where no vacuum ejector equipment is fitted (typically petrol or electric locos), the vacuum will be produced by a mechanical vacuum generator mounted in the guard's van (see below). Brake actuation will be via the guard's van mounted valve, and further developments may include a standard vacuum brake box for use with non-vacuum fitted locomotives.

Guards van equipment

The guard will have a control valve which can be used to apply the brakes or attract the attention of the driver by bringing the vacuum level down in short bursts, which will be visible to the driver on his vacuum gauge. A procedure for this will be developed.

Two guard vans are fitted with mechanical vacuum generators for use with non-vacuum fitted locomotives. These are fitted with regulators to maintain a vacuum, currently set at 15 inches of Mercury.

Testing and training

The vacuum equipment described above has now undergone initial testing and found to be effective in bringing a laden train to a stand. Further testing and trials are required to prove robustness and reliability before entering service on public running days, but initial results are favourable.

The training of both guards and drivers on the system (both in terms of mechanical components and general operation) will be undertaken prior to the system being operated on trains involved in Public Running.