Generate a brake force: the actuators

We have dealt in another page that the different types of components destined to dissipate energy (brake discs, brake shoes on wheels). Generating the force is ensured by different types of actuators, adapted to each type of brake. Nevertheless, all have as main component a brake cylinder.

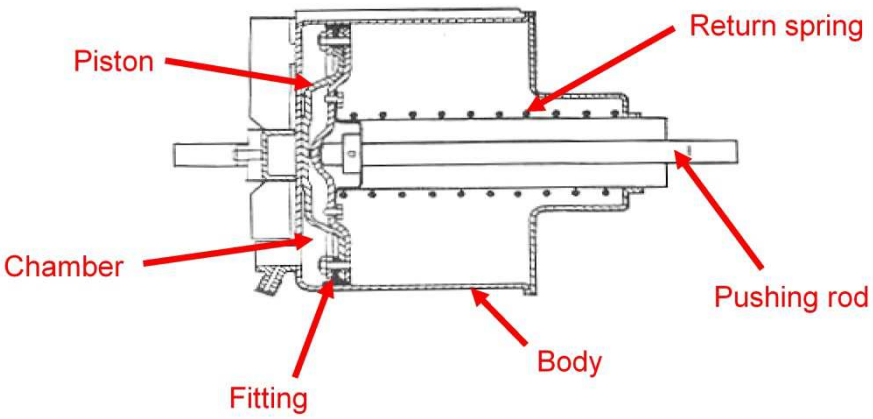
Moreover, the great majority of actuators include a device called slack adjuster, which aims at compensating the wear of friction materials (brakes shoes and disc brake pads) in order to avoid that a too important gap consecutive to wear reduces the brake force.

In the following sections, we'll have a look on the different types of actuators.

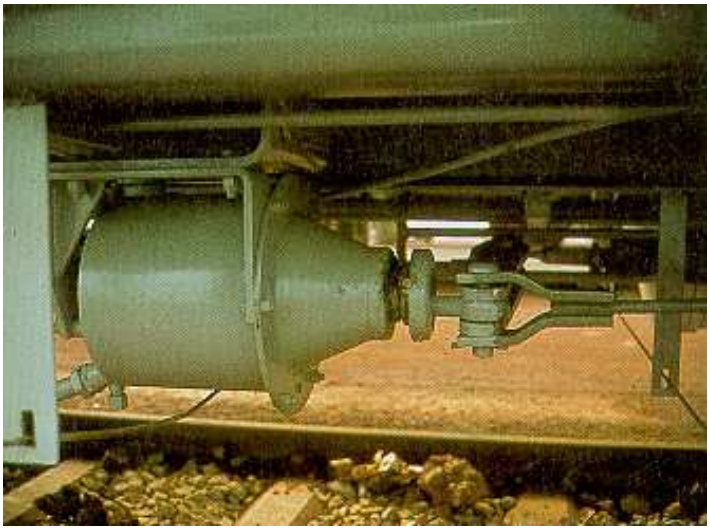
Brake cylinder and brake rigging

During tenth or years, brake force generation and transmission were performed by the same means, for a locomotive as well as for a passenger coach or a wagon.

The principle relies on a single brake cylinder, of huge diameter, installed either underframe of the vehicle or directly on the bogie. This brake cylinder is a simple piston, which actuates a pushing rod following action of the pressure applied on the piston. The final back action on the piston (for full release) is ensured by means of a low force spring.

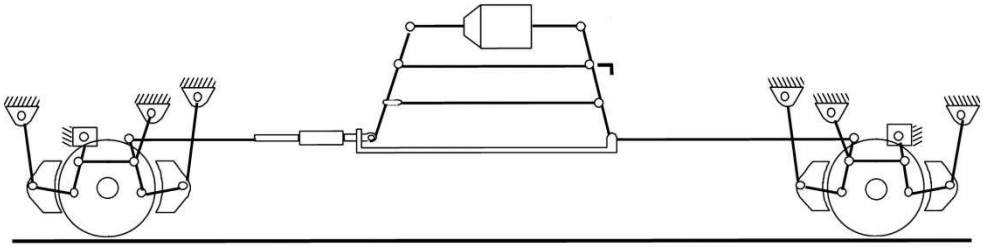


Constitution of a pneumatic brake cylinder

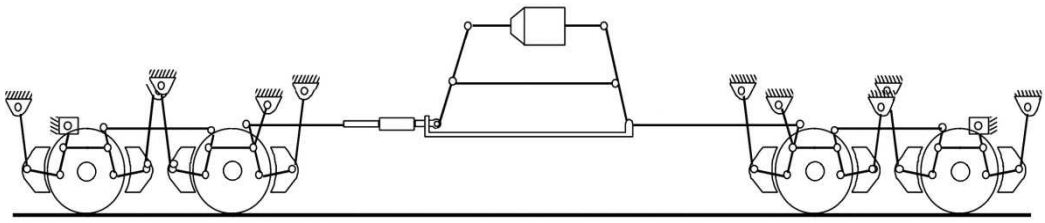


Brake cylinder on a wagon (Document FAIVELEY)

Force transmission down to the brake shors is ensured by means of a brake rigging, sometimes complex and composed of levers and rods as well as several fixed points. The lever arms which are thus obtained also enable to amplify the force generated by the brake cylinder.



Typical example of a brake rigging for a twin axles wagon



Typical example of a brake rigging for a wagon equipped with two bogies

On some wagons, a brake mode changing device makes it possible to adjust the brake level to the load status (empty or loaded) of the wagon, this in order to not too much reduce the braking performances when the wagon is loaded, as well as avoiding axle locking when the wagon is empty. This device has two positions (empty and loaded), which makes it possible to change the amplification ratio of the rigging by displacing one of the fixed points of this rigging at one end of a lever arm. The device is adjusted so as to have at mid-load the same braking power in “loaded” status than when empty on “empty” position. Decision to operate the wagon on “empty” or “loaded” position is the responsibility of the Operator, according to the effective load of the wagon.

In some cases, self-adjusting devices of the mechanical type can also be used, making it possible to continuously adjust the brake force to the load of the wagon, the load information being supplied in form of a compressed air pressure generated by a sensor included within the primary suspension.

A slack adjuster is integrated in the rigging, at a carefully selected point in order to render its adjusting capacity compatible with maximum wear of brake shoes and wheels, taking into consideration amplification of stroke generated by the different rigging levers.

Nevertheless, this architecture is essentially adapted to tread brake: the introduction of the disc brake and the need for increasing the efficiency of the tread brake and reducing its size have led to the development of new generations of actuators (see under).

The slack adjuster

The slack adjuster is a clever device that enables to keep a constant gap between the friction material (brake shoe or pad) and its counterpart (wheel or brake disc).

It is integrated in the brake rigging (for a wagon), or directly in the actuator (tread brake unit or disc brake unit : see further).

Slack adjuster for installation in the brake rigging of a wagon (Document FAIVELEY)

The slack adjuster principle is simple, although its design is quite complex and constitutes a particular know-how. Its detailed operation is also complex to describe, therefore we will not go into any more details on this matter.

Basically, the slack adjuster integrated a ball nut sliding on a screw that is interdependent from the pushing rod transmitting the force of the cylinder. When brake is applied, the nut goes forward by rotating on the screw, for a longitudinal distance that corresponds to the wear generated during the previous braking, this in order to keep a constant gap between brake shoe and wheel of brake pad and disc, this gap being pre-adjuster. The slack adjuster is defined to compensate the total stroke corresponding to the maximum wear authorized and cumulated for the friction material (brake shoe or pad) on one hand, for the counterpart (wheel or brake disc) on the other hand.

Tread brake unit

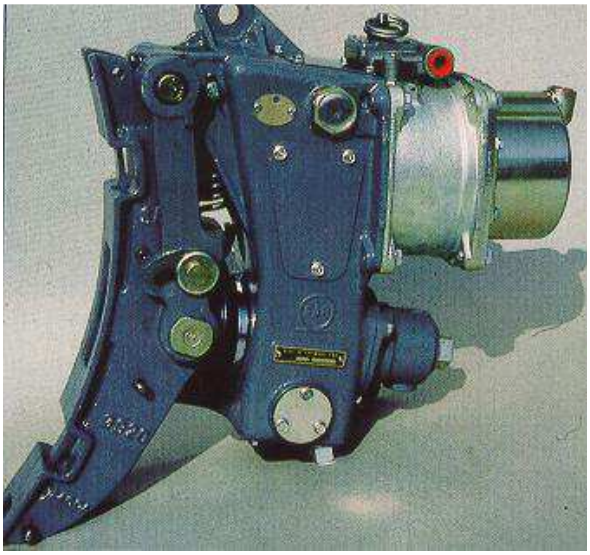
The two main drawbacks of the cylinder + rigging architecture to actuate brakes shoes are:

- A high weight
- A bad efficiency, in particular if the maintenance is not correctly performed.

This is the reason why since around thirty years, tread brake units have been developed, the principle of which being to decentralize the brake force generation (the cylinder) at the level of each weel. A tread brake unit is therefore composed of:

- A brake cylinder
- A device for amplification of the force generated by the cylinder
- An integrated slack adjuster
- A brake shoe holder.

The tread brake unit is fixed on the bogie frame, in the continuation of the wheel tread. It applies the shoe on only one side of the wheel. For some specific applications, a rigging can be used to apply a second shoe on the other side of the wheel.

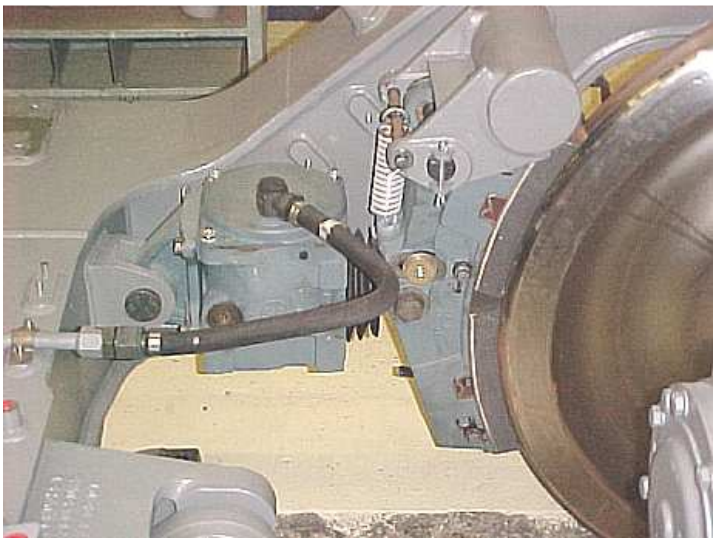


Tread brake unit for TGV or BB 26000 motor bogie (Document FAIVELEY)

Quite bulky at the beginning, tread brake units have made huge progress within the last years in terms of compactness, and become now more easy to integrate in the very “crowded” of modern bogies.

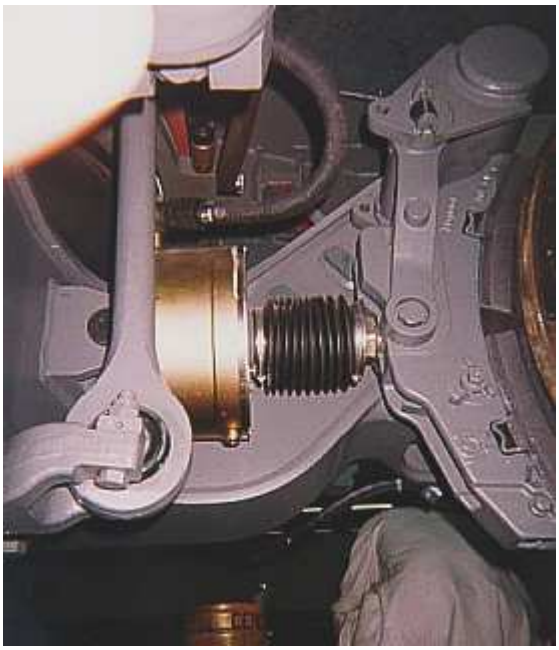
Compact tread brake unit (Document KNORR Bremse)

Depending on the brake force to apply and the energy to dissipate, it can be necessary to equip the tread brake unit with two brake shoes, which is rendered possible by using a double shoe holder.



Compact tread brake unit with double composite brake shoes on a motor wheel of the X 72500 DMU

In some cases, the tread brake only requires a low brake force, which is in the range of a simple cylinder without the need for an amplification: this is in particular the case for use in combination with a disc brake on the same axle, the latter, more powerful, absorbing the greatest part of the brake force of the axle. The brake cylinder simply integrates a slack adjuster, and directly applies the brake shoe on the wheel.

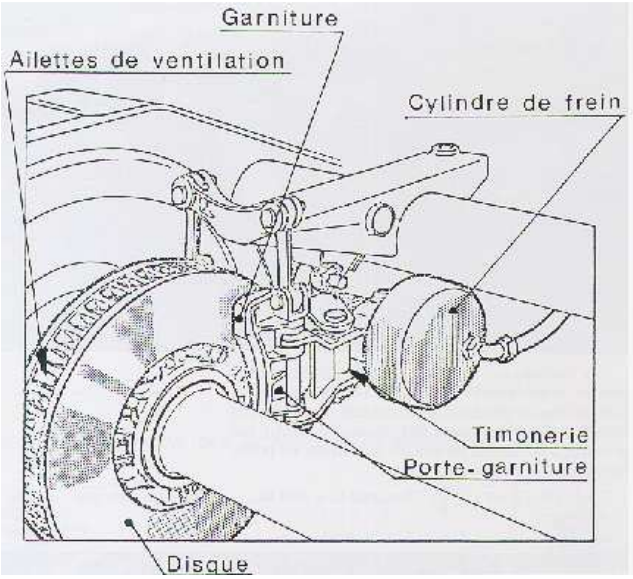


Brake cylinder with a double composite brake shoe on a trailer wheel of the X 72500 DMU

In this configuration also, it can be necessary to use a double shoe holder.

The disc brake unit

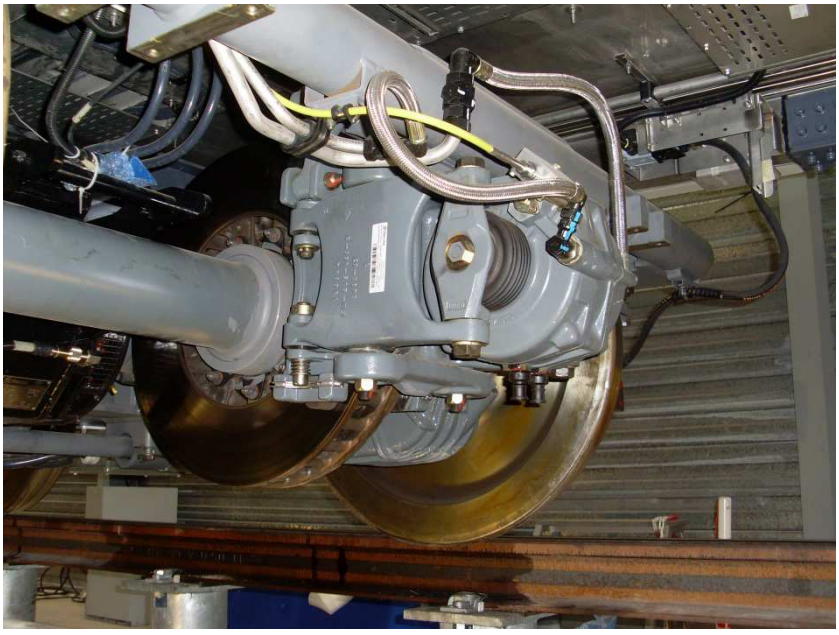
When the disc brake has been developed, it has been necessary to design specific actuators, the system composed of a single cylinder associated to a rigging being not adapted to this application.



Installation principle of the axle mounted disc brake

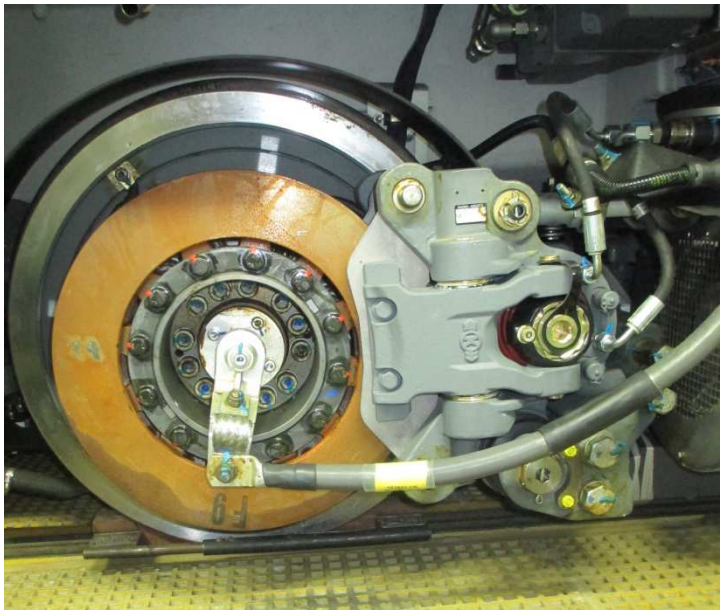
Therefore, for each disc, the actuator is composed of:

- A brake cylinder with an integrated slack adjuster
- A rigging for amplification
- A pad holder



Brake cylinder and rigging on a metro motor bogie

For the hydraulic brake (see the page dedicated to the electrohydraulic brake), the rigging is generally far more compact (because of the far higher generated forces thanks to the high pressures authorized by the use of hydraulics), eventually reduced to a single rocker or even does not exist (case of calipers similar to the ones used for automobiles).



Hydraulic caliper with rocker on a motor bogie brake disc for the CITADIS tramway

Note that for some disc brake applications requiring a high intrinsic safety for actuators (tramways and some metros), the brake cylinder is no more active but « passive »: the brake force is provided by springs (helical springs or spring washers), the pneumatic or hydraulic pressure being used to release the brake by compressing the springs.

The parking brake

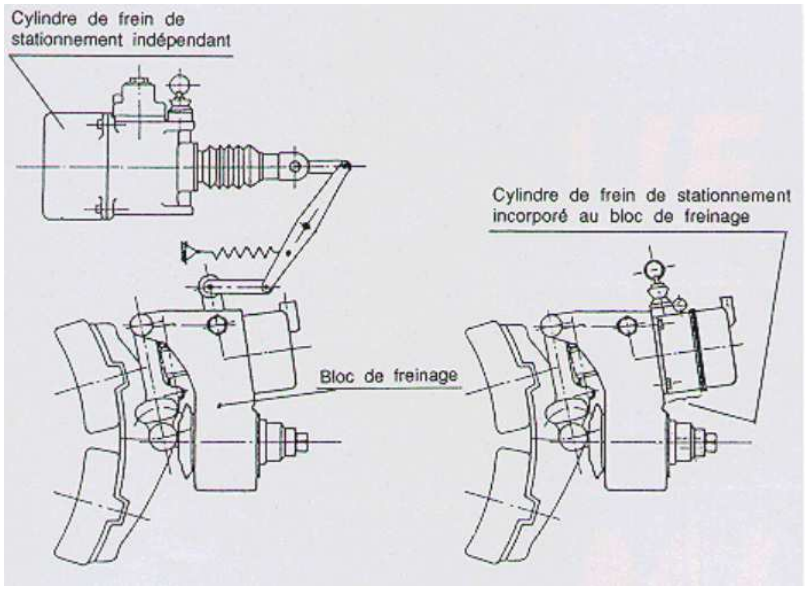
As for an automobile, a railway vehicle shall be equipped with a parking brake, the aim of which is to immobilize the vehicle when not in service.

As we have seen above, most of the actuators are of the direct type, i.e. the brake force is produced by supplying pneumatic or hydraulic energy. Therefore, it becomes necessary to add devices making it possible to provide a purely mechanical force: the vehicle should not start to move alone under action of slope or/and wind after the pneumatic or hydraulic energy has been exhausted (due to inevitable leakages).

Until recently, the parking brake was ensured by means of a cable actuated by a steering wheel installed in the carbody of the vehicle. Turning the wheel leads to wind the cable, the latter pulling on a lever which actuates the brake rigging (wagon or old passenger coach), or actuating internal levers of one of the tread brake units equipped with a parking brake equipped with a specific external lever (parking brake “plug”). Many vehicles (among which the Corail coaches) are equipped with this type of parking brake. Its advantage is that it is simple and cheap, but requires a careful maintenance as it easy goes out of right adjustment in the time.

Since about thirty years appeared spring applied parking brakes. The principle consists in:

- Either install a separate spring applied cylinder acting on the parking brake “plug” of a tread brake unit in place of the cable previously used; in this configuration, it is even possible to create an additional amplification by means of a lever arm.
- Or insert a spring applied cylinder with high capacity between the brake cylinder and the rigging of the disc brake unit or between the brake cylinder and the internal levers of the tread brake unit, this spring cylinder being able to apply a brake force in the same way as the main brake cylinder.



The two types of spring applied parking brake acting on a tread brake unit

Disc brake unit with integrated parking brake on trailer axle of the X 72500 DMU (with unlocking device by means of a cable)

During normal operation (when the vehicle is running), springs are compressed by a pneumatic or hydraulic pressure.

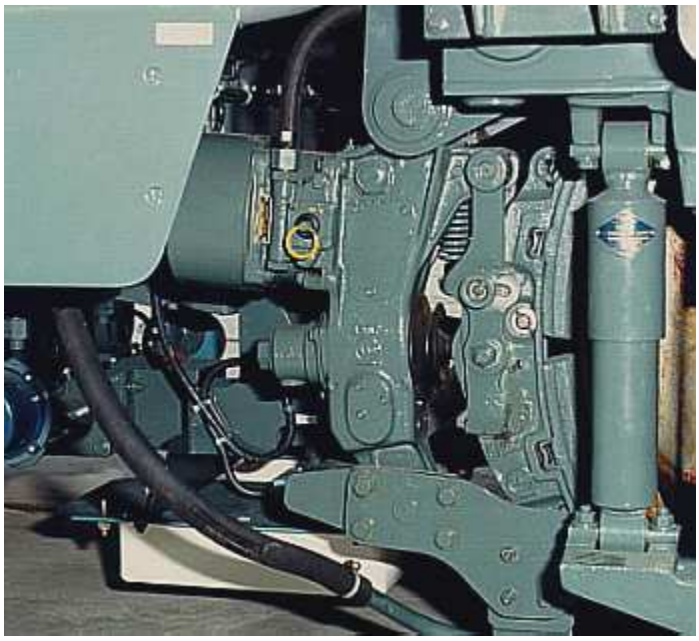
When the vehicle is set out of service:

- Either springs will substitute their force to the one of the pneumatic or hydraulic cylinder when the pneumatic or hydraulic pressure will decrease in the time, simultaneously in the main brake cylinder and in the parking brake cylinder.
- Or, before leaving his train, the driver will require venting of the spring applied cylinders, leading to springs expansion and application of the parking brake force.

When the vehicle is re-activated, control devices ensure re-pressurization of the main brake cylinders (thus generation of a force). In this case:

- Either the parking brakes are automatically re-pressurized, this leading to re-compression of springs and cancelation of their force.

- Or the driver requires the re-pressurization of parking brakes to cancel their force after being sure that brake cylinders are supplied with adequate pressure to guarantee the train immobilization.
- A mechanical unlocking device generally makes it possible to fully release the parking brakes in order to enable the movement of the vehicles and bogies in workshops during maintenance operations.



Tread brake unit with parking brake and unlocking device (yellow ring) on a BB 26000 wheel (Document ALSTOM)