The article published in the periodical “La Tecnica Professionale” no. 10-2009 described the new Italian Railways cars. The article published again in the periodical “La Tecnica Professionale” no. 10-2010 illustrated the evolution that car bogies have undergone. As we had promised, in this article we will describe the evolution of brake equipment of cars with the most significant and essential concepts.

Brake features

The UIC regulations relating to the brake (Fiche 540 and 547) provides that all vehicles must be equipped with a braking system with the following characteristics:

- **continuous** - it should be operated by a single command post and operate simultaneously on all vehicles composing the train, connected to the brake pipe;

- **automatic** - it must be automatically activated when continuity fails (breakage of the pipe or split of the train), without driver intervention;

- **adjustable** - it must be possible to operate the system both in brake and release mode with adjustable action;

- **inexhaustible** - it must not lose braking power even after repeated braking and releasing.

The braking system must also ensure the following performance, both for passenger and freight trains:

- adequate braking power to weight and speed characteristics of the convoy;
- immediacy in braking and releasing;
- absence of spurious reactions in the braking and releasing phase;
- it must be equipped with a stabilizing system, hence also with a “handbrake” (1).

**Braking concept**

A train travelling at a given speed \( V \), has a kinetic energy \( (Ec) \) which is directly proportional to half its mass and the square of its speed

\[
Ec = \frac{1}{2} m V^2
\]

\( m = \text{train mass}; \ V = \text{train speed} \)

It is commensurate with the work to be done to stop it. To stop a train we must transform its kinetic energy into thermal energy, dissipating it in the environment. This takes place by means of friction, carrying out braking work primarily through the action provided on the wheels. The force applied in this case will be the Braking Force \( F_b \), and the space \( S \) will be that required for braking.

The braking force, or braking effort, in the more traditional case, will be applied on the tyre of the wheel by means of cast-iron brake block, in a radial manner (see Fig. 1); this creates a friction effort on the edge of the wheel that has an opposite direction to the direction of motion. The effort that actually slows down the wheel is given by the product of the Radial Force \( F_r \) for the coefficient of friction \( f_a \) between brake block and tyre, expressed in the equation:

\[
F_F = F_R f_a
\]

\( F_F = \text{Braking Force}; \ F_R = \text{Radial Force}; \ f_a = \text{friction coefficient between brake block and tyre} \)

This effort creates a resistance moment that opposes the motion of the wheel

\[
M_R = F_F \cdot r
\]

If \( P \) is the weight on the wheel and \( f \) the coefficient of adhesion between wheel and rail, the wheelrail adherence force \( A \) is given by:

\[
A = P \cdot f
\]

\( A \) is the adherence; \( f \) is the adherence coefficient; \( f_a \) is the friction coefficient between brake block and tyre.

For this to occur, however, it is necessary that there is always the condition that the braking force \( \leq \) adherence; otherwise the wheels would block, but without stopping the train, originating wheel slip, causing a reduction in braking force and facets on the tyers.

As to breaking, the space

\[ (1) \text{ All passenger vehicles and only part of freight vehicles are equipped with handbrake.} \]
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within which the train has to stop, that is defined, braking space $S$, assumes an important meaning; it must be contained in the space required by signalling.\(^2\)

The braked mass of a vehicle represents the effectiveness of the brake installed on the vehicle and hence characterises the ability that a vehicle has to stop in a given space, when running at a predetermined speed, rapid braking is caused.

The braked mass of a railway vehicle, both passenger and freight, is a conventional quantity in relation to physical values such as speed and braking space, that determine its braking capacity.

The braked mass of a vehicle, referring to the mass to be braked, can be expressed as a percentage, and this relation is given the name of “percentage of braked mass” which is given by the ratio:

$$\% \text{ braked mass} = \frac{P_f}{P} \times 100$$

$P$ = mass to be braked; $P_f$ = braked mass

The braked mass of a train $P_{ft}$ is the sum of the braked masses $P_f$ of individual vehicles of the composition, including the locomotive.

Brake operation

The early cars, like the early coaches, were without brake; later the handbrake was applied, driven by the “brakeman” and placed in a special brake cabin, with which one of the cars of the train composition was equipped.

The first braking system used on railway vehicles was very simple (see Fig. 2/a), the compressed air produced by a compressor on the locomotive is sent in the general pipe that connects all the train, via a special valve, and from this in the brake cylinder, both of the locomotive and of all the vehicles. The brake blocks are pushed against the wheel tyres by the brake cylinder, through a system of levers.

This type of brake was called direct and it had two drawbacks:

- in case of breakage of the pipe there was no braking action;
- braking was very slow because it took a long time for the air to reach the tail of the train.

To eliminate these drawbacks the continuous and automatic brake was designed introducing a device called Triple Valve (Westinghouse Triple Valve) and an auxiliary tank (see Fig. 2/b) on every vehicle, between the general pipe and the brake cylinder.

In this system, as opposed to the direct brake, the pipe is always under pressure. For braking, the driver performs a depression in the general pipe, through the brake control valve and the triple valve intercepts the passage of air from the pipe to the auxiliary tank putting the latter in communication with the brake cylinder.

Vehicles with this type of brake are no longer in operation since the end of the sixties.

In order to make braking of a train more reliable and secure and adapt it to the UIC standards, i.e. make the brake: continuous, automatic, adjustable in braking releasing and inexhaustible, the triple valve has been replaced by a piece of equipment called distributor in which three pressures are compared: that of the general pipe, the brake cylinder and that of

\(^2\) Braking space must in any event not be greater than the distance between a warning signal and the next 1st category signal, plus a certain margin. This distance is usually of 1,200 m.
The operation of the brake with the distributor is based on the balance of forces acting on the three surfaces of the main plunger, located inside the distributor, on which the three pressures insist: that of the general pipe, the command tank and of the brake cylinder. With this system, the brake is inexhaustible because the brake cylinder will empty, for brake releasing, only when the regime pressure (5 bar) in the general pipe and in the auxiliary tank, equal to that of the command tank, which is isolated during the braking phase, is restored.

Train braking

To brake, the driver discharges air thus decreasing the pressure in the general pipe, depending on the intensity of braking he needs to do, through the brake control valve R (see fig. 4).

To release, he increases the pressure in the general pipe restoring it to 5 bar.

Minimum braking is achieved by lowering the pressure in the main pipe from 5 to 4.6 - 4.2 bar, with a depression of 0.6 - 0.8 bar;

Maximum braking is achieved by lowering the pressure to 3.5 bar, with a depression of 1.5 bar.

Vehicle braking equipment

Complete braking equipment of a freight vehicle (see Fig. 5), is made up of:

- pneumatic circuit;
- brake rigging.

The pneumatic circuit of the brake of each vehicle is composed of:

- a general pipe, consisting of a stainless steel tube located under the frame of the vehicle to whose ends a valve and a flexible coupler are applied consisting of a rubber tube and a coupling head that allows joining various vehicles to each other and the vehicle to the locomotive.
- a derived pneumatic circuit, connected to the general pipe that includes a number of pieces of equipment and pipes which vary according to the type of vehicle and the period in which it was built; the main elements of the circuit, are common to all types of vehicles (see figures 4 and 5) and they are:
  - isolation valve;
  - distributor;
  - command tank;
  - auxiliary tank;
  - brake cylinder;
  - automatic exhaust valve;
- a rigging, rods and levers system and braking elements. The brake rigging is the mechanical part composed of a series of levers that vary, depending on the vehicle type, as well as according to the number of brake cylinders. It has the task of transmitting the stress exerted by the pressure on the brake cylinder plunger to the brake blocks of the wheels using special multiplier ratios. The set of rods and levers is called "brake leverages" or "brake rigging."

The first distributor, mounted on FS vehicles, with full features provided by the UIC is the "Breda" distributor (see Fig. 6), fitted in 1935 and used up to the eighties.

Since 1960 a new "Westinghouse U" distributor type has been adopted (see Fig. 7). Afterwards new kinds of more reliable and more sensitive distributors were built: Westinghouse, Knoor, Westinghouse and Oerlikon. All cars built after 1978 have a stainless steel pipe.

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Oerlikon, SAB types all with the same principle that provide the same features, built with different materials and with the most advanced technologies, therefore more sensitive and more reliable.

In the seventies the distributor construction philosophy changed and the application of more modern and more sophisticated equipment has prevailed called braking "centralised groups" including in a single block: distributor, power supply relay and command tank (these were also Westinghouse, Knoor, Oerlikon, SAB type) (see figures 8÷12).

Brake rigging

The braking force required to stop a vehicle comes from the brake cylinder plunger that is pushed by the pressure of the air supplied by the auxiliary tank through the distributor. The plunger displacement is called "brake cylinder stroke", through the rigging ratio it boosts braking effort and suppresses the distance between tyre and brake block or "brake block stroke" resulting in braking (see Fig. 13).

There are two types of brake rigging in cars:

- brake rigging for two-axle cars (see Fig. 14);
- brake rigging for bogie cars with only one brake cylinder (see figures 15 and 16);
- brake rigging for bogie cars with two brake cylinders (see Fig. 17).

Braking elements are: blocks, flanges and slabs that are made of cast iron and act directly on the surface of the tyre; there are also some cars on which plastic slabs made from synthetic material are applied.

Handbrake

The handbrake is used exclusively to guarantee immobility of rolling stock during its stabling on station tracks and in order to be stopped in case of halt on a given slope due to failure or interruption of the line.

Only part of the cars is equipped with a handbrake. It is controlled manually.
using a mechanical transmission system that acts on the same brake rigging. It consists of a screw driven by a crank in the brake cabin of some cars or on the passage floor at the end of a car (see Fig. 15) or by a flywheel on both sides of the car or at one of the ends. Under normal operating conditions, the unitary pressure on the brake blocks of the pneumatic brake is approximately 8-10 kg/cm², the one achieved with the handbrake 40-50 kg/cm² i.e., 5-6 times the operation one. On cars with only one brake cylinder, the handbrake acts on all wheels (see figures 15 and 16) on those with two cylinders the handbrake acts on the wheels of one bogie only (see Fig. 17).

**Vehicle braking**

To address the braking technique of vehicles we must first examine the following considerations.

**Freight service:**

- the difference between the car weight "tare" and the load is indeed remarkable, in fact a car can load a weight that can range from 0 to 300% compared to its weight;
- the mass difference between the various cars of the composition is notable both for the difference in structure of each car, 15-35 t, and because of the different capacity, as well as for the entity (in weight) of the same load on each car.

**Passenger service:**

- the difference between the weight of a coach "tare" and that of the load (passenger weight luggage), "tare + load" is in general limited (tare = 38-44 t approximately and load = 4-5 t approximately), i.e. 0-12%);
- the mass difference between the various vehicles of the composition is limited.

**In addition:**

- for passenger service braking and releasing times are faster because the operating speed is higher and the braking action must be both quick and vigorous, so as to quickly achieve high pressure on brake blocks against the wheels (releasing time 15-20 sec.);
- in freight service braking and releasing times are lower because not all vehicles are braked and braked ones have significantly different braking percentages depending on if they are empty, partially loaded or loaded (see Fig. 18), (releasing time 45-60 sec.);
- the average operating speed in freight service is less than the passenger one. In freight service the braking action is slower, if it were strong and quick as in the passenger service it would create dynamic reactions between the different vehicles due to the diverse mass, something that does not happen in passenger vehicles, where they are all braked and the braking action is of almost identical intensity.

The composition of a passenger train is usually 150-360 m long (5-12 coaches), while that of a freight train is of 200-500 m, with a far greater number of cars\(^4\).

In freight vehicles, as has already been said, the weight of the load can vary from 0 to 300% compared to the weight of the car "tare." In order to eliminate excessive dynamic imbalances that would have been created among several cars of the composition, during the braking and
 dependent on the type of car, the tare and hence the braked weight, the auxiliary tank capacities and especially that of the brake cylinder vary, while the distributor can be the same. In order to adequate the distributor, the calibrated supply plugs of the auxiliary tank and those for supply and exhaust of the brake cylinder can vary.

Devices for braking adjustment

The braking adjustment devices are of two types (see Fig. 19):

• "Freight-Passenger" device for the adjustment of braking and releasing times;
• "Empty-load" device for the adjustment of braking power as the load varies.

Freight-Passenger Device

This device has the task of adjusting the filling and discharge timing of the brake cylinder. The device applied on all those cars that are predisposed to travel also in composition with passenger trains is operated by a handle of the "freight-passenger" device, "M - V" or "G - P", placed on both sides of the car (at the centre).

This handle can be placed on G (or M) for freight type braking or on P (or V) for the passenger one. The device operates on a plate applied on the distributor (see figures 6 and 7), which prepares and places the appropriate calibrated holes of the distributor to adjust filling and discharge timing of the brake cylinder.

Since the beginning of the application this device has not undergone any change.

Empty-Load Devices

Braking equipment of a car is generally proportionate in order to achieve a braking effort with percentage just under 100 percent of the tare, in the case of braking with an empty car. This means that when loaded, its braked weight is insufficient and will always be increasingly lower the greater the magnitude of the load. As a result, in case of braking, the train
will not stop in the spaces provided, with imaginable consequences.
The Empty-load devices are designed to make the braking effort adjustment possible when the vehicle weight (tare + load) exceeds a certain value, so that braking is constant in percentage as the load on the car varies.

The empty-load devices on FS cars are of two types:
• two-stage braking devices;
• “automatic-continuous” type devices.

Two-stage braking devices
Cars with two-stage braking Empty-load devices are equipped with V-C braking handle (empty-load) on both sides (see figures 19-21 and 26); three digits are shown on the handle plate:
• the one on the left indicates the “Empty” position;
• the one on the right indicates the “Load” position;
• the centre bottom one is called “reverse weight”.

If the tare-total load is less than the value shown on the reverse weight, the handle should be placed to the right on V; if the tare-total load is greater, the handle should be placed on C.

Two-stage devices are controlled mechanically and pneumatically.

Mechanical devices
These are two types of devices that mechanically vary the multiplication ratio of the brake rigging horizontal levers, N type and Galante type; both systems operate by varying the fulcrum point of the rigging drive levers by making tie-rods 3 or 4 operate (see figures 20 and 21).

Pneumatic device
It predisposes the pneumatic part of the brake, in case of braking, to create two levels of pressure in the brake cylinder. The device is operated with the same empty-load lever; to achieve this the pneumatic circuit was changed (see figures 23-25), inserting a pressure transformer or a power relay between the distributor and the brake cylinder.

With the pressure transformer, for full braking in an empty position, the pressure in the cylinder is approximately 2.3 bar; in the Load position it is approximately 3.7 bar.

On cars with pneumatic device two kinds of supply relays PT1 and PT2 are installed, on which the maximum pressure in the braking phase is:
• with PT1 relay, 3.8 bar in the "load" position and 2.2 bar in the "Empty" position;
• with PT2 relay, 3.8 bar in the "load" and 1.7 bar in the "Empty" position.

Automatic-continuous braking devices
With the changing requirements of customers, with the adaptation of the capacity per axle of lines (22.5 t • axis), cars with increased capacity were built. It was therefore necessary to find other systems capable of adjusting the braking effect to the actual magnitude of the load, in a complete manner for the whole field of variation ΔQ of the load loaded on cars.

To meet this requirement new “Automatic-continuous” type braking devices were adopted, capable of ensuring the pressure in the brake cylinder during the braking phase, automatically variable, so that braking is constant in percentage with respect to the load. Therefore, Automatic-continuous Empty-load devices do not require any manual command operation, as in earlier systems.

Automatic-continuous systems are also with mechanical and pneumatic command.

Automatic-continuous mechanical devices
Automatic-continuous mechanical devices are fitted on two-axle cars, there are two types, Galante type (see figures 31 and 31a) and SAB type (see Fig. 32).

Both devices consist of a piece of “weighing” equipment and of a set of levers that connect the leaf springs of the suspension to the variation mechanism of the load on the car. The variation in the braking effort during braking is driven by the same weight of the load that automatically affects the multiplication ratio of the brake rigging system, which acts on the horizontal lever arms, varying their ratio between a pre-set minimum and a pre-set maximum. Within these limits the braking effort is therefore always proportionate to the gross weight of the vehicle, resulting from the tare plus the load up to the limit indicated on the vehicle itself.

Automatic-continuous Westinghouse type pneumatic device
For the operation of automatic-continuous mechanical devices it was necessary to modify the diagram of the pneumatic circuit, introducing the “weighing devices” and the "differential automatic-control devices".

Fig. 27 - Braking diagram with pneumatic 2-pressure stages Empty-load device
Fig. 28 - Automatic-Continuous braking device diagram
The operation is based on the use of "a weighing device" fitted on the car suspension (both two axles cars and bogie cars), (see figure 33), which carries out the continuous analysis of the load weight regardless of the state of wear of the suspension itself, providing pilot pressure to the "pneumatic relay" or "differential automatic-control device". The pressure from the weighing device, in the case of braking, measures out the pressure from the distributor to be sent to the brake cylinder (from 1.3 ±1.5 bar with an empty car and 3.8 bar at full load).

For cars with well-distributed axial weights the installation of a single weighing device is adequate; the following alternatives exist in case of loads poorly distributed on the axles:

![Fig. 29 - Pneumatic diagram and car brake rigging Eanos series (dis. FS)](image)

![Fig. 30 - Bogie cars brake rigging with pneumatic Empty-load Westinghouse device (dis. FS)](image)

![Fig. 31 - Auto-continuous Galante type mechanical device](image)

![Fig. 31a - Automatic-continuous Galante type mechanical device, the arrow indicates the weighing device](image)

![Fig. 32 - Automatic-continuous "SAB" type mechanical device Type 1 = brake cylinder; 2 = balancing arm; 3 = horizontal lever; 4 = foothold; 5 = elastic blade](image)

![Fig. 33 - Westinghouse centralised group placed under the Sdgmnss series car frame](image)

The p1 and p2 pressure values that act on the brake cylinder are equal to a maximum depression in the main pipe both in the "Empty" position and in the "Load" position.

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![Fig. 33 - Westinghouse centralised group placed under the Sdgmnss series car frame](image)
• only one automatic continuous relay connected to two weighing devices;
• two automatic continuous relays each with one weighing device.

SAB pneumatic auto-continuous devices

These devices have the feature that the "braking is strictly proportional to the load". They automatically adjust the braking power to the weight of the car and make it possible to obtain a braked weight noticeably always equal to the weight (tare + load). There are various types of SAB devices (see figures 34-41).

SAB AC type device

The device is mounted on bogie cars and on those with two axles; it consists of:
• a DP1 pressure modulator (see Fig. 34) placed between the axle-box and the frame of the bogie that is affected by the load born by a suspension spring, connected to the AC device;
• an AC pressure device.

During loading of the car, the modulator, supplied by compressed air from the auxiliary tank, generates a command pressure proportional to the load. This pressure is transmitted to the weighing device servomotor that compresses the control pressure transmitted by the servomotor in the same proportion with proper effort for each braking.

In bogie cars with only one rigging system, which involves a single automatic-continuous system connected to two bogies, the Pressure Modulators are mounted in series; it is the modulator subjected to the minor load that determines the pressure transmitted to the servomotor, thus preventing that a poorly distributed load causes an excessive braking effort, with the consequent risk of locking the wheels.

Figure 34 shows the AC type automatic-continuous device mounted on a two-axle car, also armed with SAB DP1 type Automatic Pressure Modulator. The weighing device is connected, by means of a lever compensating system, located on one side of the car to the rings of the two suspension springs.

During the loading of the car the weighing device is compressed in proportion to the load born by the suspension springs.

SAB AC3 type device

The device (see figures 37 and 38) consists of two parts:
• "the weighing equipment", which determines the extent of variation in relation to the actual weight on the car;
• the "DAB-AC3 device that varies the rigging ratio.

The magnitude of the variation in the rigging ratio is determined by the load on the internal suspension springs ends of a side of the car.

Levers 1, connected to the internal ends of the suspension springs, through the leverages, act on the weighing spring of the SAB-AC3 device with a force proportional to the weight of the car; it is clear that any change in weight of the car changes the bending of spring 7 and consequently changes the position of the mobile fulcrum 9.

In the case shown in Figure 37, where the axles have different loads $Q_1 < Q_2$, the effort acting on tie rod 8 is greater than that acting on tie rod 4, and the balancing...
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levers move to the right until connecting rod 3 rests on the bottom of the tie rod fork itself.

Under these conditions, the effort acting on tie rod 8 is without effect on weighing spring 7 that is solely controlled by the effort acting on tie rod 4.

As a result, when the loads are different, the position of mobile fulcrum 9 is therefore established by the less loaded axle of the car. The device adjusts the braking effort to the less loaded axle, so as to avoid any risk of slippage.

SAB AC3D type device

It is applied on cars equipped with Y 25 type bogies; it is a completely pneumatic device. The diagram is that of figures 40 and 41. Sensitive components are: the DP1 pressure valve and the AC Automatic-continuous Device.

SAB-Oerlikon devices

(see figures 42 and 43)

Knorr-Bremse auto-continuous device

It is installed on Megafret type cars Sffgmnrrss series, consisting of two units coupled by interface traction/repulsion devices with fixed locking, suitable for intermodal transport; equipped with Y 33 bogies with monoblock wheel sets and 730 mm wheel diameter.

SAB AC3D type device

It is applied on cars equipped with Y 25 type bogies, 18 t tare, braked weight max 56 t with handbrake.

Fig. 38 - Diagram of pneumatic brake circuit with SAB AC3D type automatic-continuous device 1 - general pipe; 2 = central braking group; 6 = auxiliary tank; 7 = filter; 9 = AC devices; 10 = weighing valve; 11 = flexible connections (Sigeu cars)

Fig. 39 - SAB AC3 type automatic-continuous device directly on the Y 25 bogie type; DP1 = weighing valve

Fig. 40 - Brake rigging of Sg series cars with SAB AC3D Automatic-continuous type system, Y 25Cs type bogies, 18 t tare, braked weight max 56 t with handbrake

Fig. 41 - Diagram of the pneumatic circuit of the SAB brake system, operating on Poche cars, series Sdgmnss 1 - general pipe; 2 = head valve; 3 = central braking group; 4 = auxiliary tank; 5 = weighing valve; 6 = ARL 150 pressure regulator; 7 = brake cylinder; 8 = bogie brake rigging; 9 = isolation valve

Fig. 42 - Pneumatic brake circuit, with automatic-continuous system, Westinghouse and SAB Oerlikon, applied on Poche cars equipped with Y 31 C7 bogies type 1 = general pipe; 2 = head valve; 3 = central braking group; 4 = auxiliary tank; 5 = weighing valve; 6 = ARL 150 pressure regulator; 7 = brake cylinder; 8 = isolation valve

Fig. 43 - SAT Oerlikon distributor. Diagram of the pressure in the full braking phase: the pressure in the brake cylinder of an empty car is 0.5 bar, and 3.9 bar for a loaded car.
The weighing device is installed on the axle-box inserted between the suspension springs and the frame (see figures 46 and 47); it is the system that converts the weight variation in a proportional pneumatic command and consists of membrane 3 blocked by gaskets 4 and 5 that serve as interface supports.

When a force pushes piston 2 proportional to the weight of vehicle Q, it makes membrane 3 arch upwards, while exerting a force on pin 6 that drives membrane piston 7. The strength of the membrane piston 7 pneumatically controls the device through shaft 8. The pneumatic control of the device consists of an input valve V1 and output valve V2.
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Conclusions

Safety of the operation of a train is particularly entrusted to the efficiency of the braking system. In fact, the brake equipment test of the whole convoy ("brake test") is usually a necessary condition before the departure of the train. The operating characteristics of the rail brake must be contained within fairly narrow parameters so that a uniform behaviour for all rolling stock that are in the same train composition can be ensured. In modern cars constant percentage braking as the load varies is required. For this reason appropriate devices to achieve automatic-continuous braking of the load were applied on the cars. These devices allow the variation of the braking effort to be achieved mechanically or pneumatically or with a combination of both systems.

For more detailed information we recommend enthusiasts and researchers to refer to the new volume published by CIFI, "The Railway vehicle - Cars".

Fig. 46 - Weighing device. Assembly of the device on the axle-box. Interior of the device and elastomer 1 = body; 2 = piston; 3 = membrane; 4 and 5 = gaskets; 6 = piston; 7 = piston membrane; 8 = shaft; 9 = head valve; 10 = spring; 11 = spring; 12 = check valve; d1, d2 and d3 = orifice; f = beat; v1 = input valve; v2 = output valve; Q = weight of the vehicle; R = auxiliary tank pressure; T = control pressure; O = air discharge

References

[9] Regolatore di pressione tipo LDR e Relais di pressione Oerlikon tipo ALR - SAB Broms SpA.
[10] Distributore pneumatico del freno tipo ESG - Oerlikon Frenisistemi - FI.

Fig. 47 - Pneumatic circuit of the brake equipment on twin type Megafret cars, series Sffggmrss, with Knorr-Bremse systems 1 = KEd distributor; 2 = G-P service change device; 3 = isolation valve; 4 = C.G. semi-coupling; 5 = head valve; 6 = automatic rigging control; 7 = brake cylinder; 8 = auxiliary tank (75 l); 9 = nut; 10 = flexible connection; 11 = hall holder; 12 = screw cap; 13 = K1-E outlet for measures; 14 = flow choke; 15 = T2 measurement socket; 16 = weighing valve