ANTI SKID SYSTEM

FOR HIGH SPEED INDIAN COACHES

COPIA CONFORME

ANNEXED:

Dwg. 407601:	µWUPAR antiskid Control Unit
Dwg. V11207:	Floating connector bracket
Dwg. V11525:	Sliding rack support
Dwg. 239655:	Junction box
Dwg. 317401:	Speed sensor
Dwg. 217251:	Dumping and rebraking valve

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COPIA CONTROLLATA

1. Introduction

The µWUPAR anti skid device for High Speed Indian Coaches derives very closely from the similar one installed on the ETR 480 Pendolino trains.
It makes use of an operating principle tried and tested successfully over many years by Elettromeccanica Parizzi, which has now been improved with state-of-the-art technology.

It works as a pressure regulator of the air contained in the brake cylinders, and adjusts the braking force to the wheel-to-rail adhesion conditions in order to prevent the wheels from locking and to reduce the braking distance.
Satisfactory performances are bound to the capabilities of the brake system acting on the disk to promptly react, releasing the axle in case of a pressure step down or braking again when the pressure is increased again.

The µWUPAR device is made up of two microprocessor-driven modules which control the state of adhesion of the axles and of one supervisor module for diagnostic purposes.

By a specific technical and commercial negotiation, (optional functions), the device can be optionally fitted with independent functions, the airflow at the input and outlet of the brake cylinder and to issue the alarm signals.

Such a document takes into account the previous technical specification issued on 16.01.1997 by Linke Hofman Bush GmbH, the following discussions and amendement and goes much further into details.

Instruction Manual is based on Parizzi format.

1.1. General

The functional principles and operating logic of the new device fully originate from the original tried and tested WUPAR anti skid system.
The newly introduced logics have been implemented in order to enhance the degree of reliability of the system and ensure greater flexibility in the management of adverse conditions in the event of a failure of any of its parts.

In keeping with the original operating principles, with a satisfactory dry-rail adhesion coefficient the device does not interact with the pneumatic system.
The device enters into action when a loss of adhesion of the axles is detected and, moment by moment, it adjusts the braking force to the present adhesion conditions.

The action of the device is controlled in order to keep the skidding wheel in the most favourable area of the adhesion-skid characteristic.

The system employs two electro-pneumatic assemblies on each bogie.

This document describes a 4 axle-4 channel configuration, in which the system detects speed and operates penumatic assembly each separate axle selectively.

2. Reference Standards

The µWUPAR anti skid system is on the whole designed to comply with the following national and international standards, with only a few exceptions for which a waiver will be requested and alternative solutions will be technically motivated.

UNI	In general for the drawings
UNI and DIN	In general for the mechanical parts
CEI UNEL	In general for the cables and conductors
CEI 20-17 (2nd. Ed.)	Self-extinguishing and inflammability characteristics
Italian Leg. 26/06/84	Reaction to fire
IEC 571-1	Electronic equipment used in railway applications
IEC 77	Rules for electric equipment
prEN 50155	Railway application - electronic equipment used on rolling stock
EIA standard RS485	Electrical characteristics for digital multi-point systems
UIC 541-05	Antiskid

3. µWUPAR Anti skid System

The proposed µWUPAR system comprises the following components:

Q.ty	Description	
1	µWUPAR control unit in a rack	dwg. 407601
1	Floating connector bracket	P/N 007.02.365
2	Sliding Rack supports	P/N 069.31.076
4	Rapid discharge assemblies	P/N 100.14.080
2	Right connection boxes	P/N 004.01.609D
2	Left connection boxes	P/N 004.01.609S
4	Speed sensors,	P/N 004.02.842
1	Set of connecting cables (excluded power supply to the Control Unit)	
1	Toothed wheel,	P/N 013.24.434

Through negotiated modifications it is possible to operate such a system in the following conditions:

- up to speed of 200 km/h
- on a locomotive, with an additional module to drive a speedometer.

4. General characteristics

- Number of processing units: 3 (1 per bogie + 1 supervisor)
- Number of axles controlled: 4
- Number of outputs or channels: 4 (one for each electrovalve assembly)
- V1 intervention threshold: see diagram in Fig. 2
- V2 intervention threshold: see diagram in Fig. 2
- DEC intervention threshold: see diagram in Fig. 2
- ACC intervention threshold: 1.6 m/sec²
- Deceleration of fictitious axle: 1.75 m/sec²
- Deceleration of fictitious axle in synchronous skidding: 1.35 m/sec²
- Overall response time (electric-pneumatic): ≤ 200 mS
- Rated supply voltage: 110Vdc
- Short-circuit protection: permanent

The electrical connections with the device are made by multiple connectors.

The system is taylored for Indian Coaches with 2 bogies each car and two axles per bogie.
Actual maximum speed is 160km/h and, with some adaptations it can be rised up to 200 km/h.

Wheel diammeter:	- new: 915mm - worn: 845mm minimum	
ambient conditions:	temperature inside the coach:	0-55°C
	maximum temperature in sun:	70°C (before service)
	Humidity:	100% non condensing

N.B.: fig. 2 is given just as an example and will be adjusted and fine tuned at the final issue of the design.

5. µWUPAR control unit

The unit performs the following functions:

- Detection of 4 axle signals from the magnetoresistance principle-based sensors
- Measurement of peripheral speed (Vp)
- Calculation of reference speed (Vr)
- Wheel diameter automatic compensation
- Processing of accelerometric and tachymetric operation criteria
- Safety timers
- Reset criteria for failure signals
- Criteria of bogie device out of order or not powered
- Unprotected Axle
- SKID/SLIDE criterion
- On-line diagnostics
- Off-line diagnostics
- Record of failures

The door-lock criteria is also provided: such a criteria can be used also to lock/unlock toilettes doors.

The Printed Circuit boards come in the standard EUROCARD 100 x 160 format, with F or H shaped DIN 41612 connectors.
This solution enables the modules to be positioned in the 84-TE 3-unit DIN rack, in line with the current tendency to centralize all the control boards of the different systems in a single cabinet in order to rationalize the available resources.

The µWupar Control Unit is made up of the following modules:

Q.ty	Description
2	Power supplies (ALIM modules) to feed all electronics, speed sensors and electropneumatic subassemblies.
1	USDR fitted with 8 relay output.
2	MWCP, a µProcessor module to drive pneumatic subassemblies.
1	MWCT an optional local diagnstic unit with a display and a clavier to easy interface operators with electronic unit.
1	MIB to filter battery voltage for Control Unit.
2	MWCO that are analogic interface from/to the extern each one related with one MWCP.

5.1. Detection of 4 axle signals from the magnetoresistance principle-based sensors

The µWUPAR control unit supplies the 4 speed sensors with the biasing current required to generate a signal whose amplitude is compatible with the correct operation of the system under the worst-case application conditions (Maximum air gap).

This function is obtained by using current generators which also allow the electric mesh relative to the generator to be checked constantly and, if the connection becomes open or short-circuited, give the diagnosis of "generator disconnected" or "generator short-circuited".

The pulses coming from the frequency generators are proportional to the number of axle revolutions and are amplified and converted into digital data as a function of the peripheral wheel speed and the effective wheel diameter.

Each bogie µWUPAR device controls and manages the signals originating from the two axles of the relevant bogie.

5.2. Peripheral speed measurement (Vp)

Each bogie device constantly processes the speed (Vp) of the axles directly connected to it and continuously compares this value with the reference speed (Vr) of the vehicle; it also regulates the air pressure in the brake cylinders by means of the pneumatic valves, in order to keep the skidding in the area enclosed between speed thresholds (V1) and (V2), i.e. the most favourable zone for restoring adhesion.

The purposely delimited free skid zone has thus been conceived to keep the wheel rolling planes intact.

Fig. 1 illustrates the operating logic.

5.3. Calculation of reference speed (Vr)

Each individual bogie device calculates a reference speed which is an estimate of the real speed of the vehicle.

In general, the device takes the speed of the fastest axle as the effective vehicle speed.

In the event that all the axles simultaneously lose adhesion, the reference speed follows a pre-set law of variation which adapts to the deceleration rate of the vehicle until at least one axle regains adhesion.

5.4. Wheel diameter automatic compensation

The peripheral speed of each individual axle is closely correlated to the real wheel diameter; this diameter is identical for all the axles when the vehicle is new, but eventually it may vary, within the allowed tolerance range, due to wear and to the turning operations that wheels must undergo with time.
The automatic compensation function compensates for the differences between the wheel diameters.

This function operates automatically whenever the system detects a constant speed for long periods of time on all the axles.

5.5. Processing of accelerometric and tachometric operation criteria

The operating criteria V1, V2 and DEC are calculated by each individual bogie device as a function of speed, while the value of the ACC criteria is fixed.

5.5.1. Axle negative acceleration criterion (DEC)

This criterion controls the rapid discharge valve and causes the brake cylinder to be emptied when the negative acceleration (Ai) exceeds the reference value (DEC).
In turn, the DEC criterion is corrected by the speed of the vehicle, as illustrated in Fig. 2 (as previously mentioned, this curve is just showed as an example).
This value is 4m/sec² from speed "0" to 20 km/h; it then linearly increases up to a maximum of 6 m/sec², and is kept constant for speeds in excess of 120 km/h.

5.5.2. Axle negative acceleration rebrake criterion (EVRDEC)

In newer systems we introduced this new criterion that acts in order to reduce discharge events. In fact when the negative acceleration on an axle reaches a value that is:

$$EVRDEC \geq 0{,}75 * DEC$$

the system reacts by powering rebraking valve so stopping pressure increasing in the brake cylinder.

5.5.3. Axle positive acceleration criterion (ACC)

This criterion operates the rebraking electrovalve when the recovery reacceleration of the axle (Ai) exceeds the reference value (ACC).

5.5.4. Speed comparison criterion (V1)

With decreasing axle speed (Vi) < (V1), the rebraking valve is operated; thus no more air can enter the brake cylinder.

With axle speed (Vi > V1), the rebraking valve is released, and air may again enter the brake cylinder.

The value of V1 is adjusted as a function of the vehicle speed, as illustrated in Fig.2.

$$V1 = Vr - (1{,}5\ km/h + \frac{6 * Vr}{100})$$

5.5.5. Speed comparison criterion (V2)

This criterion operates the de-braking electrovalve (Rapid discharge valve) in order to empty the brake cylinder when the axle speed is (Vi) < (V2).

With axle speed (Vi) > (V2), the electrovalve is reset and no further air can be released from the brake cylinder.

Criterion V2 is also a function of the vehicle speed, as illustrated in Fig. 2.

$$V2 = Vr - (2{,}5\ km/h + \frac{24 * Vr}{100})$$

5.5.6. Pneumatic assembly control Logic

Based on the preceding considerations, the pneumatic assemblies are controlled in order to:

a) reduce the pressure to the brake cylinders with:

$$Vi \leq V2 \text{ or } Ai \leq DEC$$

b) restore the pressure to the brake cylinders with :

$$V1 \leq Vi \text{ or } Ai \geq ACC$$

c) maintain the pressure to the brake cylinders if neither condition a) nor condition b) is satisfied, that is:

$$V2 \leq Vi \leq V1 \text{ or } DEC \leq Ai \leq EVRDEC$$

As is shown in Fig. 1.

5.6. Safety timers

Each bogie µWUPAR continuously monitors the status of its EVS and EVR electrovalves, and if they stay on for longer than the maximum time envisaged, it automatically cuts off the command to the relevant electrovalves.

5.7. Reset criteria for failure signals

Failure conditions may be reset in either of the following ways:

- manually
- automatically - by exceeding the speed of 15 km/h, or by powering up the device

5.8. Criteria of system out of order or not powered

The device supplies, via a relay contact, the indication of malfunctioning or unpowered system.

Through the internal diagnostic, it is possible to investigate which bogie is affected by a fault.

5.9. Axle unprotected

Through the internal diagnostic, it is possible to investigate which axle is unprotected in case of a fault.

This information appears on the display of the rack when the µWUPAR is unable to control at least one of the two bogie axles involved, or when there is a failure of an axle control electrovalve.

5.10. Door lock criterion

The µWUPARs detects the speed, supplying the following criteria:
Speed $\geq$ 6 km/h - relay de-energized contact open
Speed $\leq$ 3 km/h relay energized contact closed

5.11. On-line diagnostics

The bogie µWUPAR modules and the CENTRAL µWUPAR cyclically test the integrity of their own processing functions, the actuators and the status of the sensors and transducers they are connected to.

In the event of a malfunction, corrective actions are undertaken to isolate the function, actuator or transducer suspected of having failed, in order to minimize any decline in system performance levels.

5.12. Off-line diagnostics

For the actual batch of coaches built by Linke Hoffman Bush the µWUPAR system features a user interface with a keyboard and alphanumeric display located on the front of the CENTRAL µWUPAR.

Such a module is generally not foreseen in the scope of the supply for each Control Unit and is generally given as a diagnostic unit in some samples for the whole batch of system supplied.

This interface enables maintenance and troubleshooting functions to be carried out.
The maintenance inspection operations can be carried out only when the train is stationary.

5.13. Failure logging

The CENTRAL µWUPAR system permanently stores all failure conditions detected by the diagnostic functions in a non-volatile memory.

All stored events can be displayed and erased if necessary via the functions that can be selected from the off-line diagnostics menu.

5.14. Failure criterion

In case of any failure or loss of alimentation an external relay contact will be close.

6. Diagnostics

The µWUPAR system diagnostics was developed to comply with the procedures used by the maintenance organizations operating in the Railways.

All diagnostics except the one described in chapter 7 are runtime so they don't need any activation command.

6.1. First level signals

The device supplies externally the following first level diagnostic information: "µWupar faulty".

6.2. Second level diagnostic informations

The CENTRAL µWUPAR device will supply all second level diagnostic information directly to the local display unit.

A brief description of the second level diagnostic information follows.

6.2.1. Axle generator disconnected

This signals that the relevant generator connection is open.

6.2.2. Axle generator short-circuited

This signals that the relevant generator connection is short-circuited.

6.2.3. Rebraking electrovalve disconnected

This signals that the electric connection of the relevant rebraking electrovalve is open.

6.2.4. Rebraking electrovalve short-circuited

This signals that the electric connection of the relevant rebraking electrovalve is short-circuited.

6.2.5. Debraking (rapid discharge) electrovalve disconnected

This signals that the electric connection of the relevant debraking electrovalve is open.

6.2.6. Debraking (rapid discharge) electrovalve short-circuited

This signals that the electric connection of the relevant debraking electrovalve is short-circuited.

6.2.7. Rebraking electrovalve cut out

This signals that the rebraking electrovalve (EVR) has been cut out, as a result of the action of the relevant safety circuit.

6.2.8. Debraking electrovalve cut out

This signals that the debraking electrovalve (EVS) has been cut out, as a result of the action of the relevant safety circuit.

6.2.9. USDR failure

The system checks runtime the USDR module and it signals a failure every time it detects an uncorrect status of any relay.

7. µWupar device check

The check is performed with the vehicle stationary.

The testing methods and type depend on the optional functions implemented.

The various tests on the µWUPAR device may be carried out locally via the keyboard/display interface.

The tests are consist of: anti skid test and door lock test.

The test results are displayed locally on the display unit and/or on the external warning panel, if fitted.

7.1. Anti skid test

When the "anti skid test" sequence is run, it starts up the following internal and external components of the device, as follows:

- Rapid discharge commad check (EVS)
- Rebraking command check (EVR)
- door lock test

One axle at a time is tested, each time ensuring that the train is stationary.

8. Functional analysis of the system parts

8.1. Speed sensor

The speed sensor generates a pulse frequency proportional to the number of revolutions and teeth of the phonic wheel.

It comprises a magnetic sensor which exploits the principle of magnetoresistance, by which the value of the resistance across the sensor terminals is modulated by variations of the air gap in the magnetic circuit made up of the phonic wheel and the sensor itself.

No active components or complex hybrid circuits that could amplify the signal are built into the sensor.

Thus, the presence of one single component, the magnetoresistor, enhance reliability of the speed sensor, in comparison with more complicated systems.

Technical specifications:

- Induction: ≥ 1500 GAUSS
- Typical magnetoresistor value: 165 ± 50 Ω (air gap + ∞ 21°C)
- Minimum ΔR (air gap 0 + ∞): ≥ 100 Ω (minimum)
- Maximum resistance with air gap = 0: ≤ 380 Ω
- Dielectric strength voltage with respect to earth: 750Vac 50Hz for 1'
- Insulation resistance: ≥ 100 M Ω
- Temperature range: -40°C + +125°C
- Frequency range: 0 + 20kHz
- Shocks: 1500g for 1,5 ms
- Vibrations in the three directions: 35 g (10 + 200Hz)
- Magnetoresistor type: FP 30 L 100 E (Siemens)
- MTBF: 100,000h
- Max. biasing current: 35mA

8.2. Connection box

The connection box is identical to the ones fitted on previous anti skid systems and it is used to ensure connection between the speed sensor cable (belonging to the bogie) and the signal cable lied to the Control Unit (belonging to the car body shell).
Drawing 239655/... illustrates the overall dimensions.

8.3. Pneumatic discharge assembly

One single assembly contains the pneumatic debraking electrovalve (EVS) and rebraking electrovalve (EVR), which decrease, maintain or increase the pressure to the brake cylinder according to the debraking and rebraking commands of the anti skid device.

As seen in the pneumatic circuit illustrated in Figure 3, with the valve (EVR) energized, a gauged passage is cleared between the main pneumatic duct and the brake cylinder.

This opening is justified by safety reasons, and, with the rebraking valve (EVR) energized, it allows a slow increase in pressure inside the brake cylinder, which does not interfere with the skidding axle's ability to exploit the stable zone of the adhesion/skid characteristic.

- **Characteristics**
  - Weight: 5.5 kg
  - Maximum operating pressure: 8.4 bar
  - Energizing dead time: ≤ 50 mS
  - De-energizing dead time: ≤ 25 mS
  - Temperature range: -30°C + +70°C
  - Supply voltage: 110Vdc (-30% +20%)
  - Absorbed current: ≤ 0,3 A
  - Dielectric strength voltage with respect to earth: 1500Vac for 1'
  - Insulation class: F
  - Protection: IP 68
  - Dimensions: See drawing 217251/...

- **Vibrations that withstood in operation**
  - Frequency: 1 + 100Hz
  - Amplitude (mm):
    - $a = 25/f$ with $1 < f < 10$Hz
    - $a = 250/f^2$ with $10 < f < 100$Hz

- **Shocks**
  - Max. acceleration in the 3 directions: 50 m/sec²
  - Duration: 11 mS

9. Modifications

0	22.04.98	First issue - M.Cova/rs.
1	14.01.99	Modified points 1- 3 - 5.5.6 – 6; New points 5.5.2 - 6.2.9 - RM 11650 - M.Cova/rs.

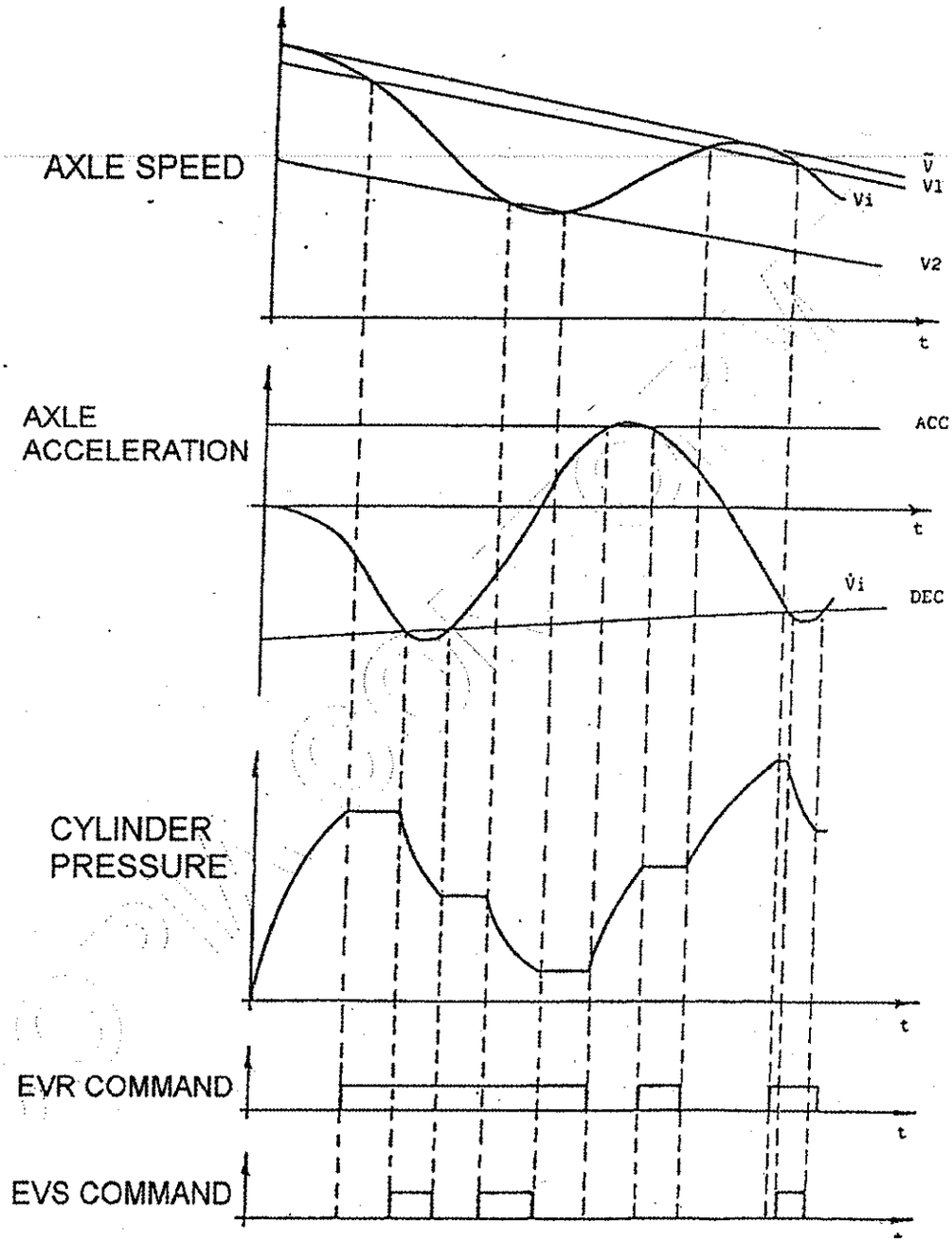


Figure 1 - LOGIC OF INTERVENTION

Errore. Non si possono creare oggetti dalla modifica di codici di campo.
Figure 2 - CURVES OF THE V1 - V2 - DEC CRITERIA

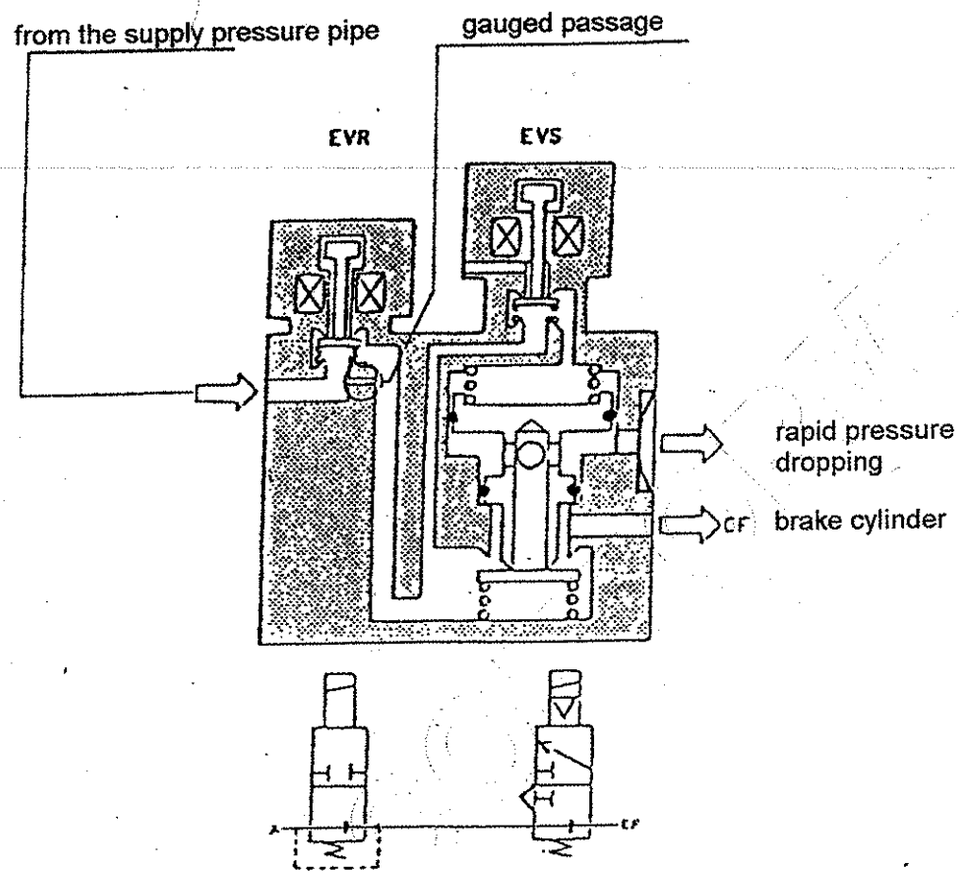


Figure 3 - PNEUMATIC CIRCUIT