

# SYSTEMS AND COMPONENTS FOR COMMERCIAL VEHICLES

## PRODUCT CATALOGUE



**WABCO**



# Systems and Components in Commercial Vehicles

Edition 2

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**WABCO**

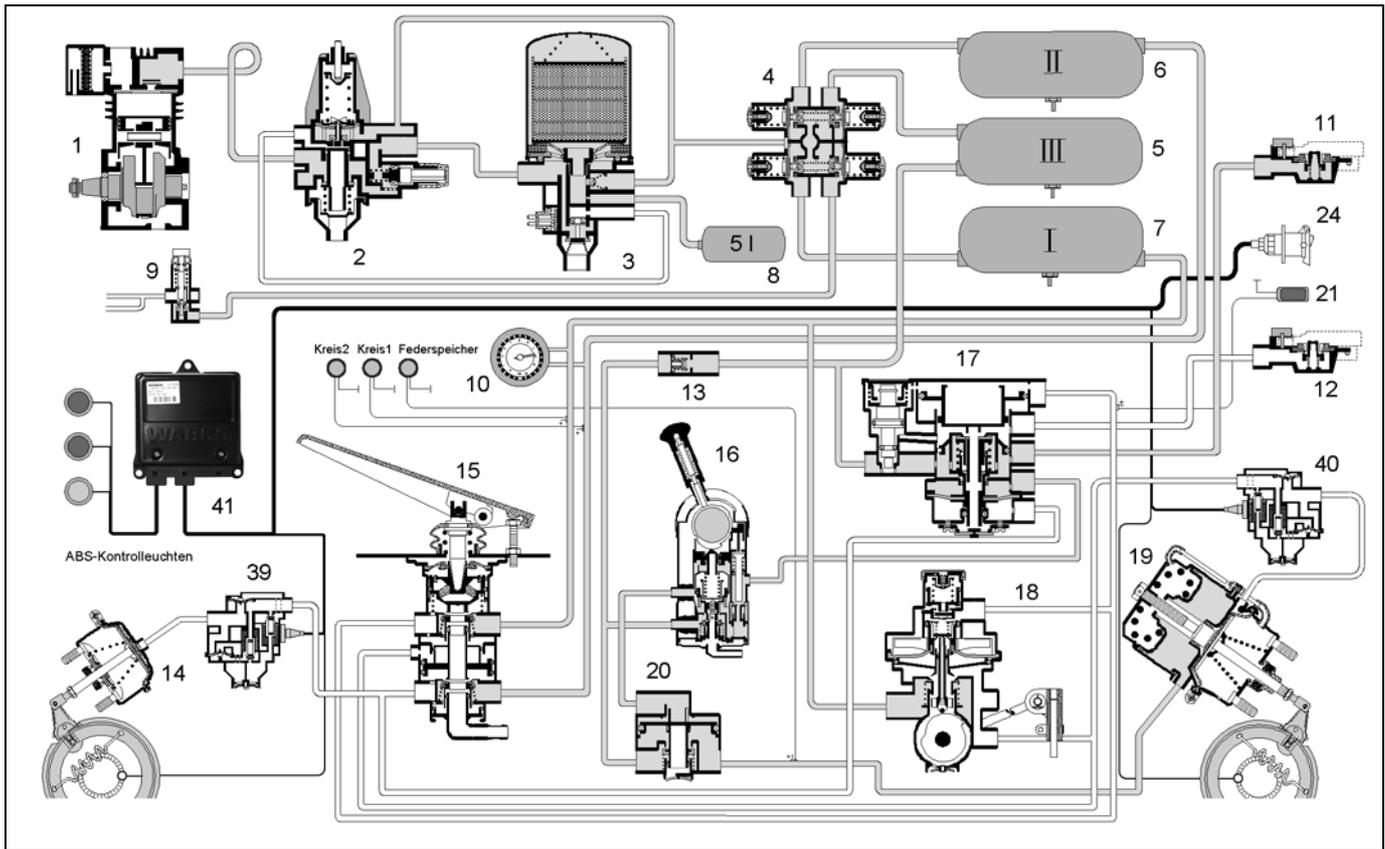
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# Operation of Air Braking Systems



## 1. Compressed Air Supply

The compressed air supplied by the compressor (1) flows to the air dryer (3) via the unloader (2) which automatically controls the pressure within the system within a range of between 7.2 and 8.1 bar, for instance. In the air dryer, the water vapour in the air is extracted and expelled through the air dryer's vent. The dried air then flows to the quadruple-circuit protection valve (4) which, if one or several circuits are defective, secures the intact circuits against any loss in pressure. Within the service braking circuits I and II, the air supply from the reservoirs (6 and 7) flows to the brake valve (15). In Circuit III the air supply from the reservoir (5) flows through the 2/2-way valve which is integrated in the trailer control valve (17) to the automatic hose coupling (11) and on to the check valve (13), the hand brake valve (16) and the relay valve (20) into the spring-loaded portion of the Tristop spring brake actuators (19). Circuit IV supplies air to any ancillary consumers, in this case an exhaust brake.

The trailer's braking system receives compressed air through the hose coupling (11) with its supply hose connected. This air then passes the line filter (25)

and the relay emergency valve (27) before reaching the reservoir (28) and also flows to the supply ports of the ABS relay valves (38).

## 2. Operation:

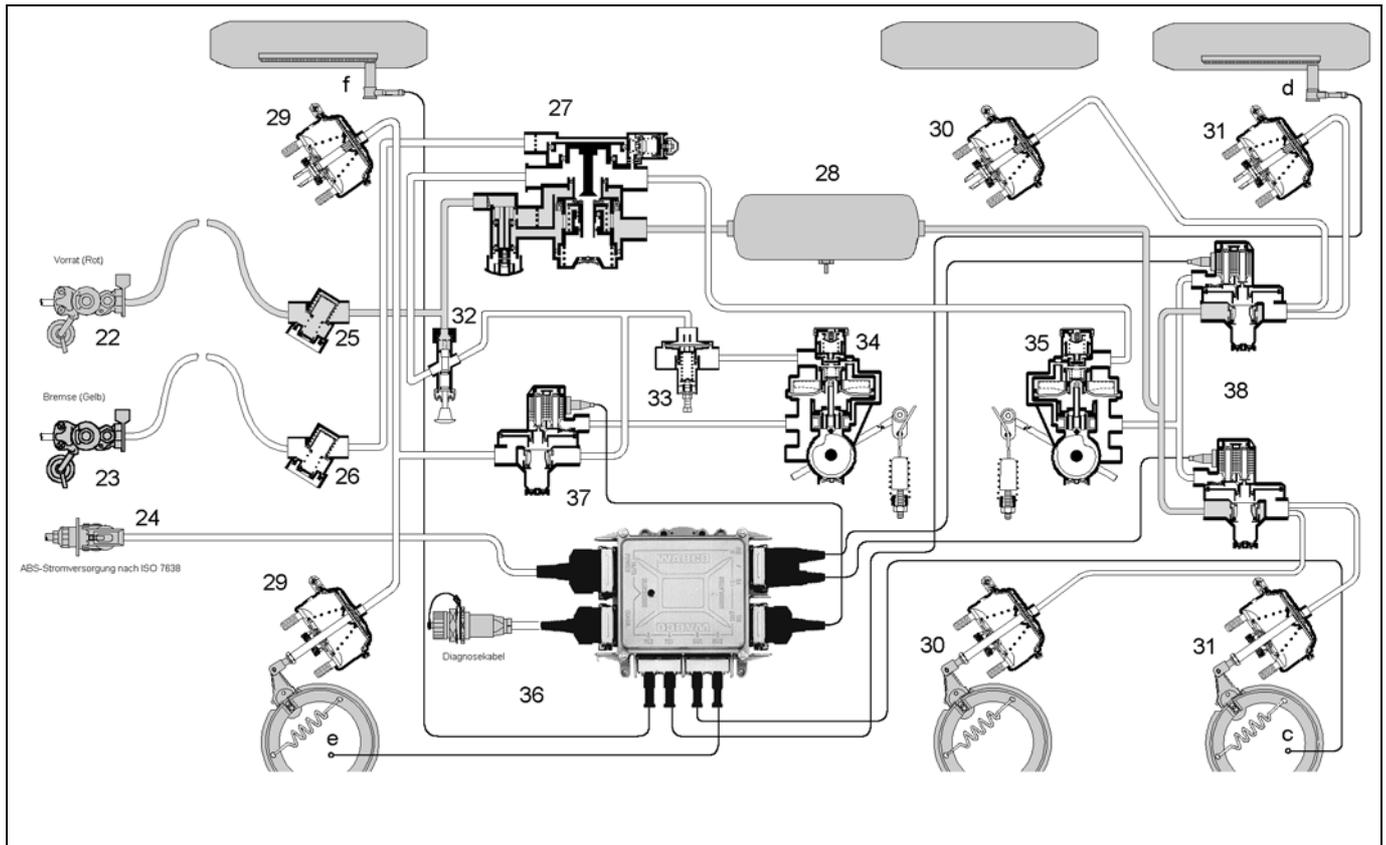
### 2.1 Service Braking System

When the brake valve (15) is actuated, compressed air flows via the ABS solenoid control valve (39) into the brake chambers (14) of the front axle and to the load-sensing valve (18). This valve reverses and the air flows via the ABS solenoid control valve (40) into the service brake portion (brake chambers) of the Tristop spring brake actuators (19). The pressure in the brake cylinders generating the force required for the wheel brake depends on the amount of force applied to the brake valve, and on the load carried on the vehicle. This brake pressure is controlled by the load-sensing valve (18) which is connected to the rear axle by means of a linkage. Any change in the distance between the vehicle's chassis and its axle caused by loading or unloading the vehicle causes the brake pressure to be continuously adjusted. At the same time, via a pilot line, the load-empty valve integrated in the brake valve is affected by the load-sensing valve. Thus

the brake pressure on the front axle is also adjusted to the load carried on the vehicle (mostly on lorries).

The trailer control valve (17) actuated by the two service braking circuits pressurizes the pilot connection of the relay emergency valve (27) after passing the hose coupling (12) and the connecting "control" hose. The air supply from the air reservoir (28) is thus allowed to pass through the relay-emergency valve, the trailer release valve (32), the adapter valve (33) and on to the load-sensing valve (34) and the ABS relay valve (37). The relay valve (37) is actuated by the load-sensing valve (34) and the compressed air flows to the brake chambers (29) on the front axle. The ABS relay valves (38) are actuated by the load-sensing valve (35), and the compressed air is allowed to pass to the brake chambers (30 and 31). The service pressure on the trailer, which is similar to the output pressure from the towing vehicle, is automatically adjusted by the load-sensing valves (34 and 35) for the load carried on the trailer. In order to prevent overbraking of the wheel brake on the front axle in the partial-braking range, the service pressure is reduced by the adapter valve (33). The ABS relay valves (on

# Operation of Air Braking Systems



the trailer) and the ABS solenoid control valves (on the towing vehicle) are used to control (pressure increase, pressure hold, pressure release) the brake cylinders. If these valves are activated by the ABS ECU (36 or 41), this control process is achieved regardless of the pressure allowed to pass by the brake valve or the relay emergency valve.

When they are not needed (solenoids are dead), the valves operate as relay valves and achieve a faster increase or decrease of the pressure for the brake cylinders.

## 2.2 Parking Braking System

When the hand brake valve (16) is actuated and locked, the spring-loaded portions of the Tristop spring brake actuators (19) are exhausted fully. The force needed for the wheel brake is now provided by the heavily preloaded springs of the Tristop spring brake actuators. At the same time, the pressure in the line leading from the hand brake valve (16) to the trailer control valve (17) is reduced. Braking of the trailer commences by the pressure increasing in the connecting 'supply' hose. Since the guideline of the Council of the European Communities (RREG) that a tractor-trail-

er combination must be held by the motor vehicle alone, the pressure in the trailer's braking system can be released by moving the hand brake lever into its 'control' position. This permits the parking braking system to be examined as to whether it fulfills the provisions of the RREG.

## 2.3 Auxiliary Braking System

Due to sensitive graduation of the hand brake valve (16) the lorry can be braked by means of the spring-loaded portions even if the service braking systems I and II have failed. The brake force for the wheel brake is produced by the force of the preloaded springs of the Tristop spring brake actuators (19) as described under 'Parking Braking System' although the spring-loaded portions are not exhausted fully but only to the extent required for the braking performance.

## 3. Automatic Braking of the Trailer

In the event of the connecting 'supply' line breaking, the pressure will drop rapidly and the relay emergency valve (27) will cause full application of the trailer's brakes. In the event of the connecting 'control' line breaking, the 2/2-way valve integrated in the trailer control valve (17)

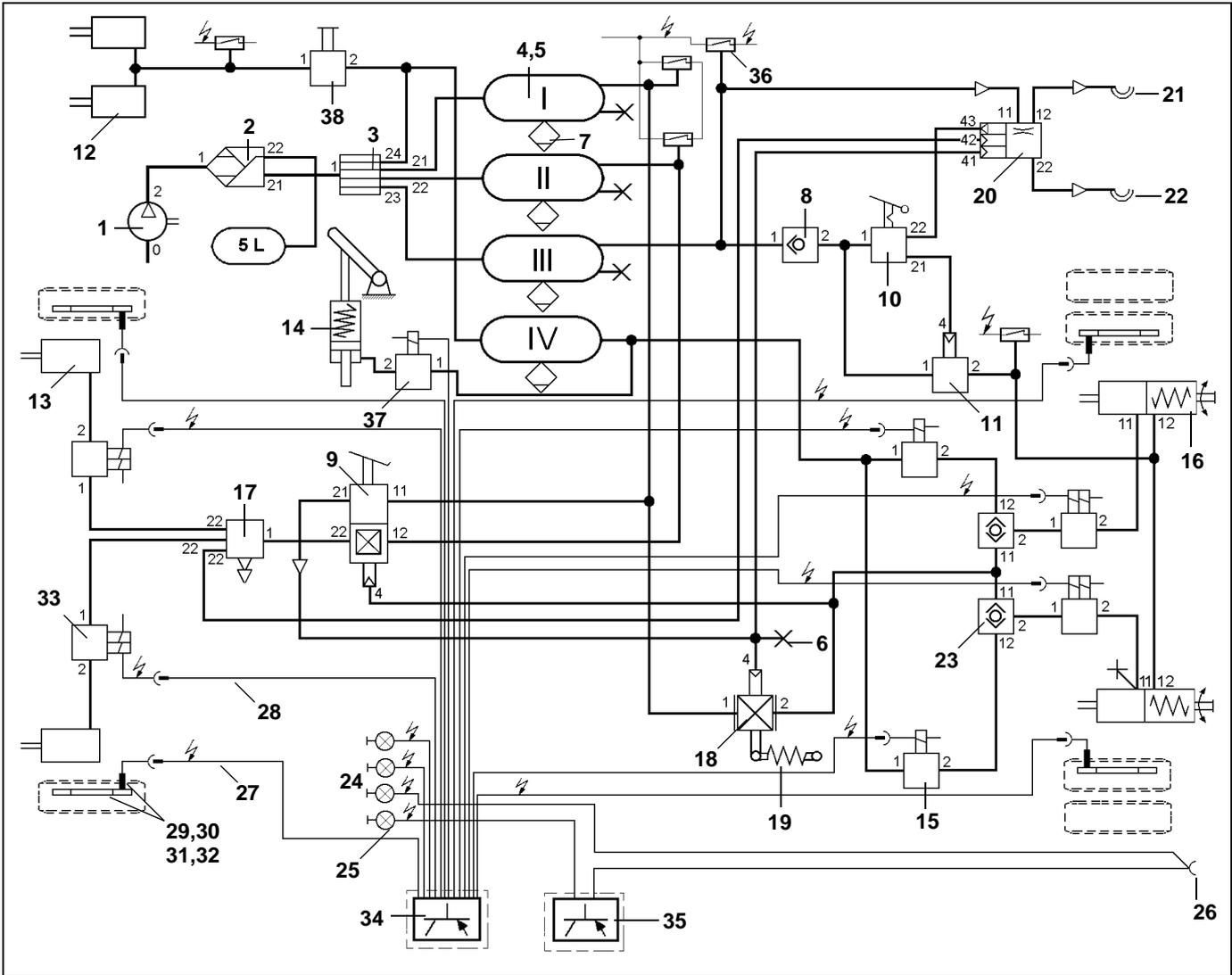
will, when the service braking system is actuated, throttle the passage of the supply line leading to the hose coupling (11) to such an extent that the rupture of the supply line causes a rapid drop in pressure in the supply line and the relay emergency valve (27) causes the trailer to be braked automatically within the legally stipulated time of no more than 2 seconds. The check valve (13) secures the parking braking system against any inadvertent actuation if the pressure drops in the supply line leading to the trailer.

## 4. ABS Components

The motor vehicle usually has three tell-tale lamps (ASR having one additional lamp) fitted for indicating functions and for continuously monitoring the system. It also has a relay, an information module and an ABS socket (24).

After actuating the driving switch, the yellow telltale lamp will come on if the trailer has no ABS or if the connection has not been established. The red lamp will go off when the vehicle exceeds a speed of approx. 7 k.p.h. and the safety circuit of the ABS electronics has not detected an error.

# Air braking system with ABS/ASR (4S/4M)



## Legend:

- |      |   |                           |                                  |
|------|---|---------------------------|----------------------------------|
| Pos. | 1 Compressor  | 15 3/2 Solenoid valve     | 31 Sensor with cable             |
|      | 2 Air dryer with combined unloader                        | 16 Tristop-Brake actuator | 32 Pole wheel                    |
|      | 3 Four circuit protection valve                           | 17 Quick release valve    | 33 ABS-Solenoid valve            |
|      | 4 Air reservoir   | 18 Load sensing valve     | 34 Electronic control unit       |
|      | 5 Clamps  | 19 Knuckle joint          | 35 Info module                   |
|      | 6 Test coupling   | 20 Trailer control valve  | 36 Pressure switch               |
|      | 7 Drain valve   | 21 Hose coupling, supply  | 37 Proportional valve            |
|      | 8 Check valve   | 22 Hose coupling, control | 38 3/2 Directional control valve |
|      | 9 Brake valve with integral auto load proportioning valve | 23 Two-Way valve          |                                  |
|      | 10 Hand control valve with trailer control                | 24 ABS Warning lamp       |                                  |
|      | 11 Relay valve  | 25 ABS Info lamp          |                                  |
|      | 12 Piston cylinder  | 26 ABS-socket             |                                  |
|      | 13 Brake chamber  | 27 Sensor extension cable |                                  |
|      | 14 ASR-Control cylinder                                   | 28 Solenoid cable         |                                  |
|      |   | 29 Socket                 |                                  |
|      |   | 30 Sensor braket          |                                  |

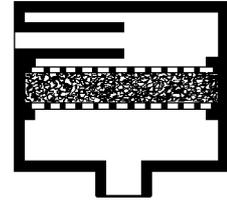
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# Components Of The Motor Vehicle's Braking System

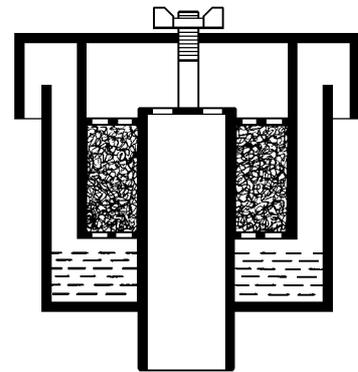
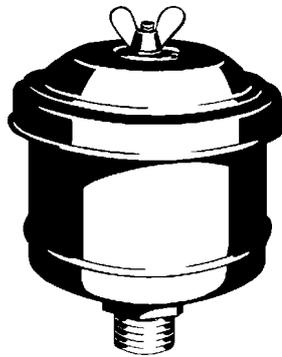
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**Moist Air Filter**

432 600 . . . 0 to 432 607 . . . 0

**Oil Bath Air Cleaner**

432 693 . . . 0 to 432 699 . . . 0

**Moist Air Filter****Purpose:**

To prevent impurities from the air getting into the compressor (by using suction filters) or into the vents of compressed air equipment (by using vent filters); they also serve to muffle the noise caused by the intake of air or by blowing it off.

**Operation:**

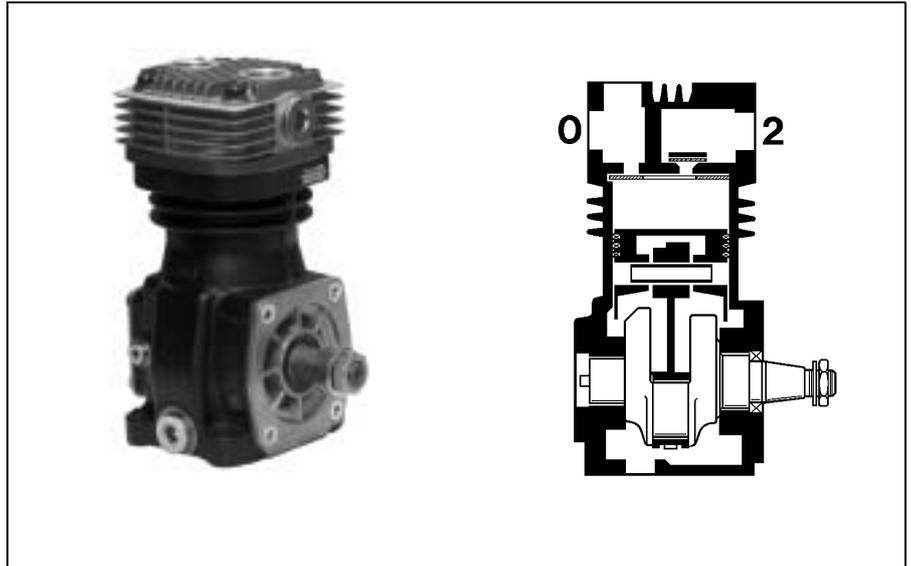
Moist air filters (for normal operating conditions). The air is taken in through an opening in the cap, flows through the filter medium where it is cleaned and then flows on to the air intake of the compressor.

**Oil Bath Air Cleaner****Operation:**

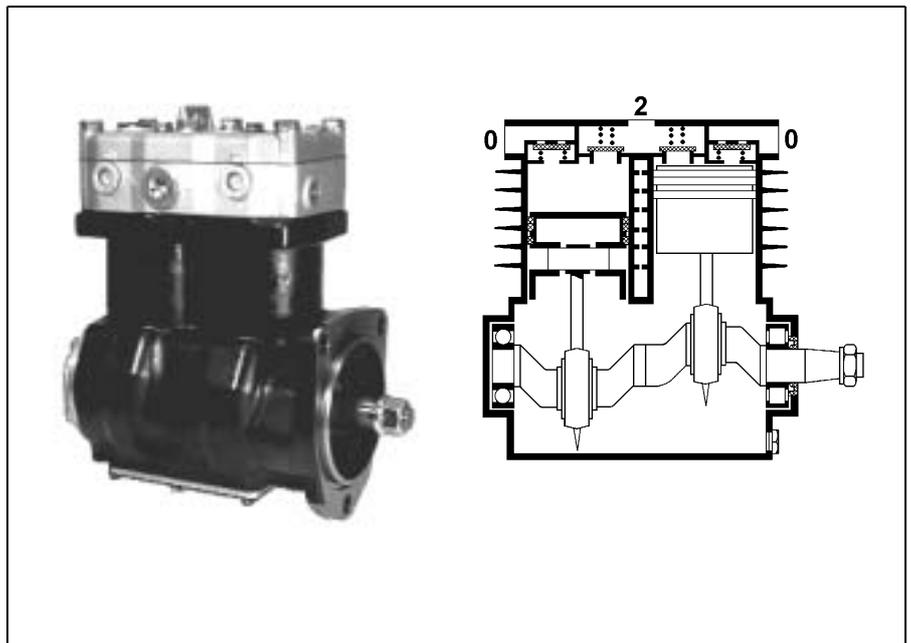
Oil bath air cleaner (for air containing a large amount of dust)

The air is taken in through the sieve plate below the cap and the central pipe, and then passed across the surface of the oil where any dust particles can settle. From the surface of the oil, the air is pushed upward, flows through a filter package which retains any impurities which may still be contained in the air and any oil particles carried over before reaching the air intake of the compressor.

**Single Cylinder  
Air Compressor**  
411 1 . . . . . 0 and  
911 . . . . . 0



**Twin Cylinder  
Air Compressor**  
411 5 . . . . . 0 and  
911 5 . . . . . 0



**Purpose:**

Production of compressed air for road vehicles and static systems.

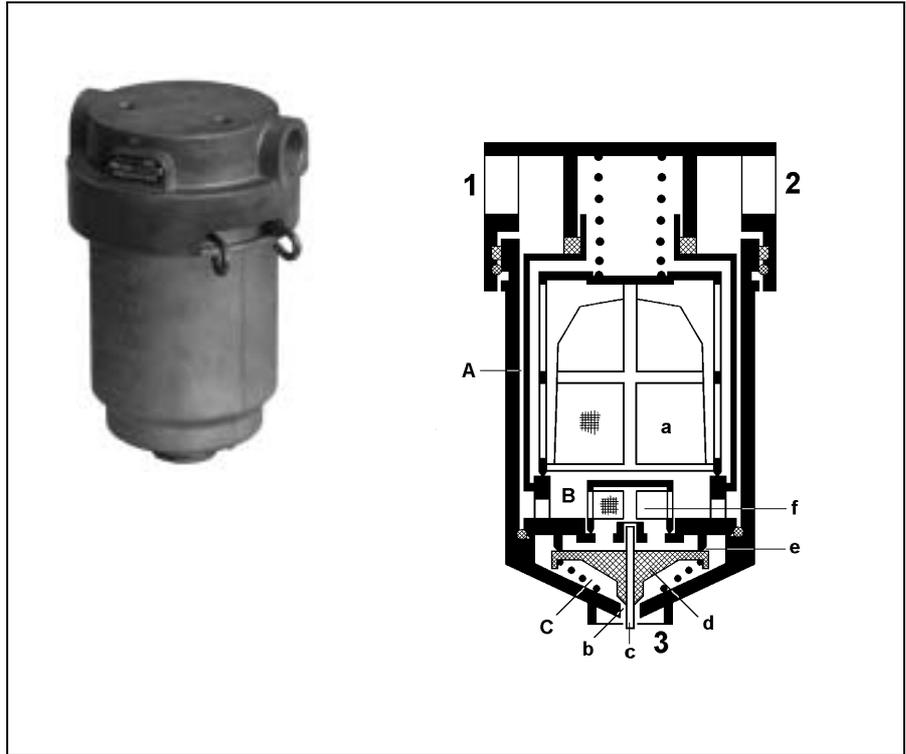
**Operation:**

The pulley on the end of the crankshaft is rotated by a vee-belt driven off the vehicle's engine. This rotation causes the connecting rods to move the pistons. As the piston travels downwards clean

air from either the engine air cleaner or the moist air filter (or alternatively an oil bath air cleaner) is drawn in through the inlet valve. As the piston moves upwards, the inlet valve closes, and air is pumped through the delivery valve into the reservoir.

The type of lubrication depends on the construction of the compressor, and can be splash or pressure fed.

**Air Cleaner**  
432 511 . . . 0



**Purpose:**

To clean the air delivered by the compressor and to precipitate the humidity it contains.

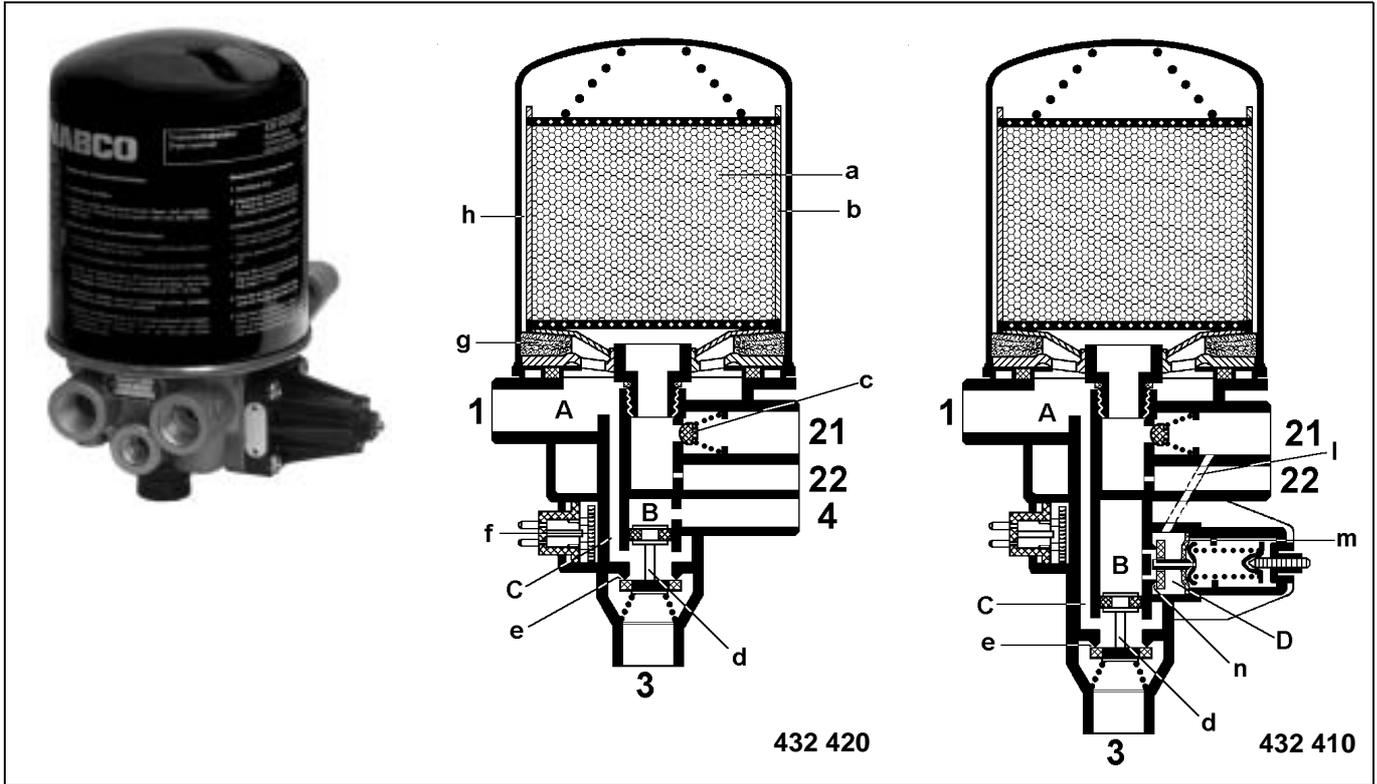
**Operation:**

The air entering at port 1 flows through annular gap A into Chamber B. As it passes through the gap A, the air cools and some of the water vapour it contains will condensate. The air then flows through the filter (a) to Port 2.

At the same time, the pressure in Chamber B opens the inlet (3) of the valve body (d) and the condensate runs through the filter (f) into Chamber C. As

the pressure in Chamber B falls, the inlet (3) closes and the outlet (b) opens. The condensate is now blown outside by the pressure in Chamber C. When the pressures in Chambers B and C are balanced, outlet (b) closes.

Pin (C) can be used to check whether the automatic drain valve is working properly.



## Air Dryer 432 410 ... 0 and 432 420 ... 0

### Purpose:

Drying of the compressed air supplied by the compressor by extracting the moisture present in the air. This is effected by a process of cold regenerated adsorption drying where the air compressed by the compressor is led through granulates (adsorbens) capable of adsorbing the moisture contained in the air.

### Operation:

#### Variant 1 (Control Via Separate Unloader Valve 432 420 ... 0)

In the feed phase, the compressed air supplied by the compressor flows via Port 1 into Chamber A. Here the condensate caused by the reduction in temperature will collect, reaching Outlet (e) via Duct C.

Via Fine Filter (g) integrated in the cartridge, and via Annulus (h), the air will reach the upper side of Desiccant Cartridge (b), being cooled in the process, and further condensate will precipitate. Moisture is extracted from the air as it passes through Granulate (a) this moisture is absorbed by the surface and the

fine ducts [diameter:  $4 \times 10^6 \text{ m} = 4 \text{ \AA}$  (Angström)] of the extremely porous granulate.

Since the oil molecules are more than  $4 \text{ \AA}$  in size they cannot enter the fine ducts of the granulates. This makes the granulate robust. The steam portion of the oil is not adsorbed. The dried air reaches the air reservoirs via Check Valve (c) and Port 21. At the same time, the dried air also reaches the re-generation reservoir via throttling port and Port 22.

When cut-out pressure in the system is reached, Chamber B is pressurized from the unloader valve via Port 4. Piston (d) moves downwards, opening Outlet (e). The air, the condensate plus any impurities and oil carbon from Chamber A will be emitted via Duct C and Outlet (e).

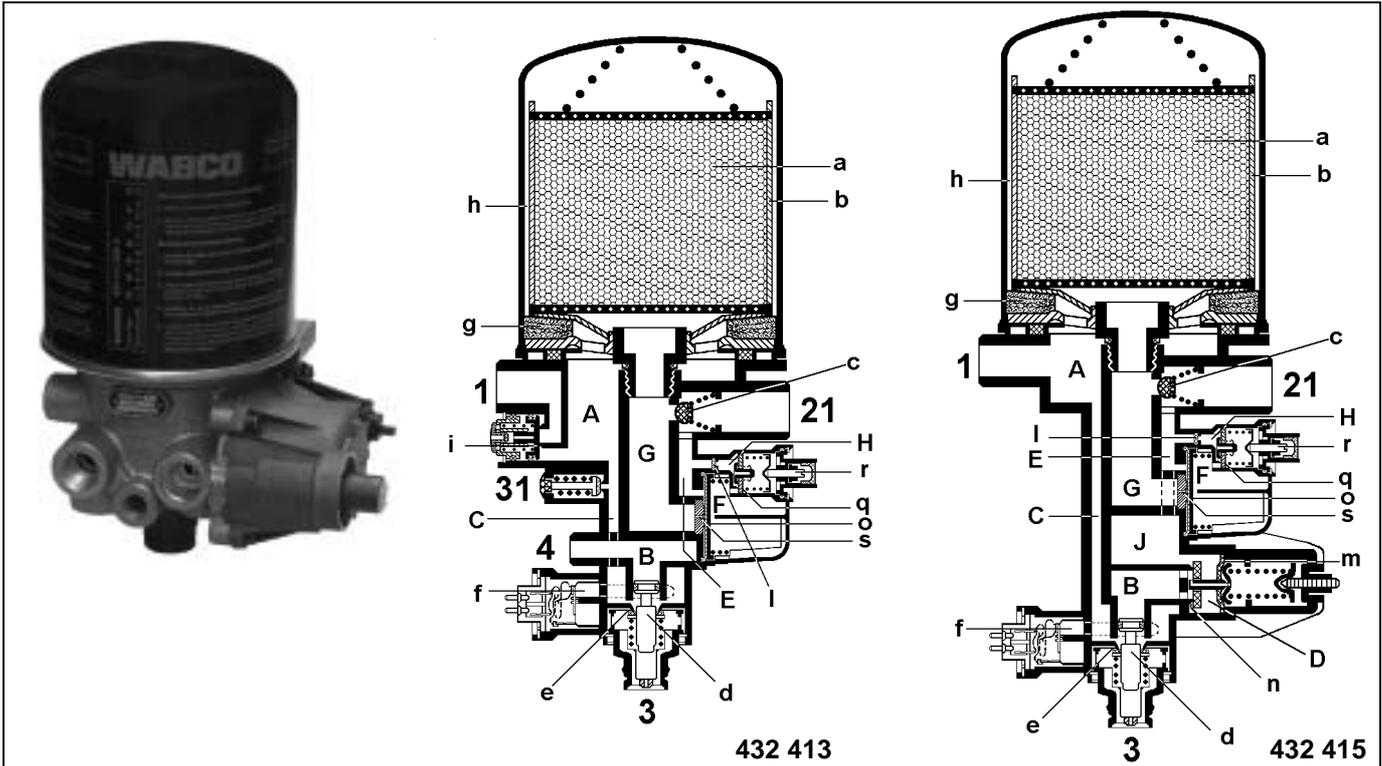
When cut-in pressure at the unloader valve is reached, Chamber B is vented once again. Outlet (e) closes and the drying process will commence as described above.

Any malfunction due to icing in extreme conditions in the area of Piston (d) can be prevented by fitting a Heating Cartridge (g) which will switch on at temperatures below  $6^\circ\text{C}$  and switch off again when the temperature reaches approx.  $30^\circ\text{C}$ .

#### Variant 2 (Control Via Integral Unloader Valve 432 410 ... 0)

The process of drying the air is as described under Variant 1. In this version, however, the cut-out pressure will reach Chamber D via Bore (l), acting on Diaphragm (m). After overcoming the spring resistance, Inlet (n) will open, and Piston (d), now pressurized, will open Outlet (e).

The air supplied by the compressor will now be emitted via Chamber A, Duct C and Vent 3. Piston (d) also acts as a pressure relief valve. In the event of any excess pressure, Piston (d) will automatically open Outlet (e). If, due to air consumption, the supply pressure in the system falls to a value below cut-in pressure, Inlet (n) will close and the pressure from Chamber B will be reduced via the unloader valve's vent. Outlet (e) will close and the drying process will commence once again.



## Air Dryer With Return-Flow Limiting Valve

432 413 ... 0 and  
432 415 ... 0

The single-chamber air dryers from this series have an integrated return-flow limiting valve which permits the required amount of air to be taken from the main reservoir provided the multiple-circuit protection valve permits a return flow. Thus no separate regenerating reservoir is required.

### Operation:

#### Variant 1 (Control Via Separate Unloader Valve 432 413 ... 0)

In the delivery phase the compressed air supplied by the compressor flows through Port 1, opens the check valve (i) and flows into Chamber A. Due to the drop in temperature, condensation water collects there which reaches the outlet (e) through Duct C.

The air is dried as described under 432 420. At the same time, dried air also flows into Chamber E, pressurizing diaphragm (o). This arches towards the right, releasing the passage between Chambers E and G via Throttling Port (s). The air supply also reaches Chamber H via Filter (l), pressurizing Valve (q). Once

the force of the pressure spring, preset by means of Screw (r), has been overcome, Valve (q) is lifted. The air supply will now reach Chamber F, acting on the other side of the diaphragm (o) with a slightly lower pressure in keeping with the retention of Valve (q).

When the cut-off pressure within the system has been reached, Chamber B is pressurized by the unloader via Port 4. The piston (d) moves downwards and opens the outlet (e). The check valve (i) closes the passage to Port 1 and the air from Chamber A flows through Duct C and is emitted to atmosphere at the outlet (e).

Due to the drop in pressure in Chamber G, the check valve (c) closes. The air to be regenerated is now taken from the air reservoirs, which is why a multiple-circuit protection valve must permit its return flow. The air supply at Port 21 flows through Chamber E, the throttling port (s) where it expands, on into Chamber G and thus to the underside of the granulate cartridge (b).

As it passes through the granulate cartridge (b) in an upward direction, the humidity on the surface of the granulate (a) is taken up by the air and emitted to atmosphere at Vent 3 after passing Duct C and the opened outlet (e). The return flow is completed when the pressure on the

left of the diaphragm (q) has been reduced to a point where it reaches its closing position.

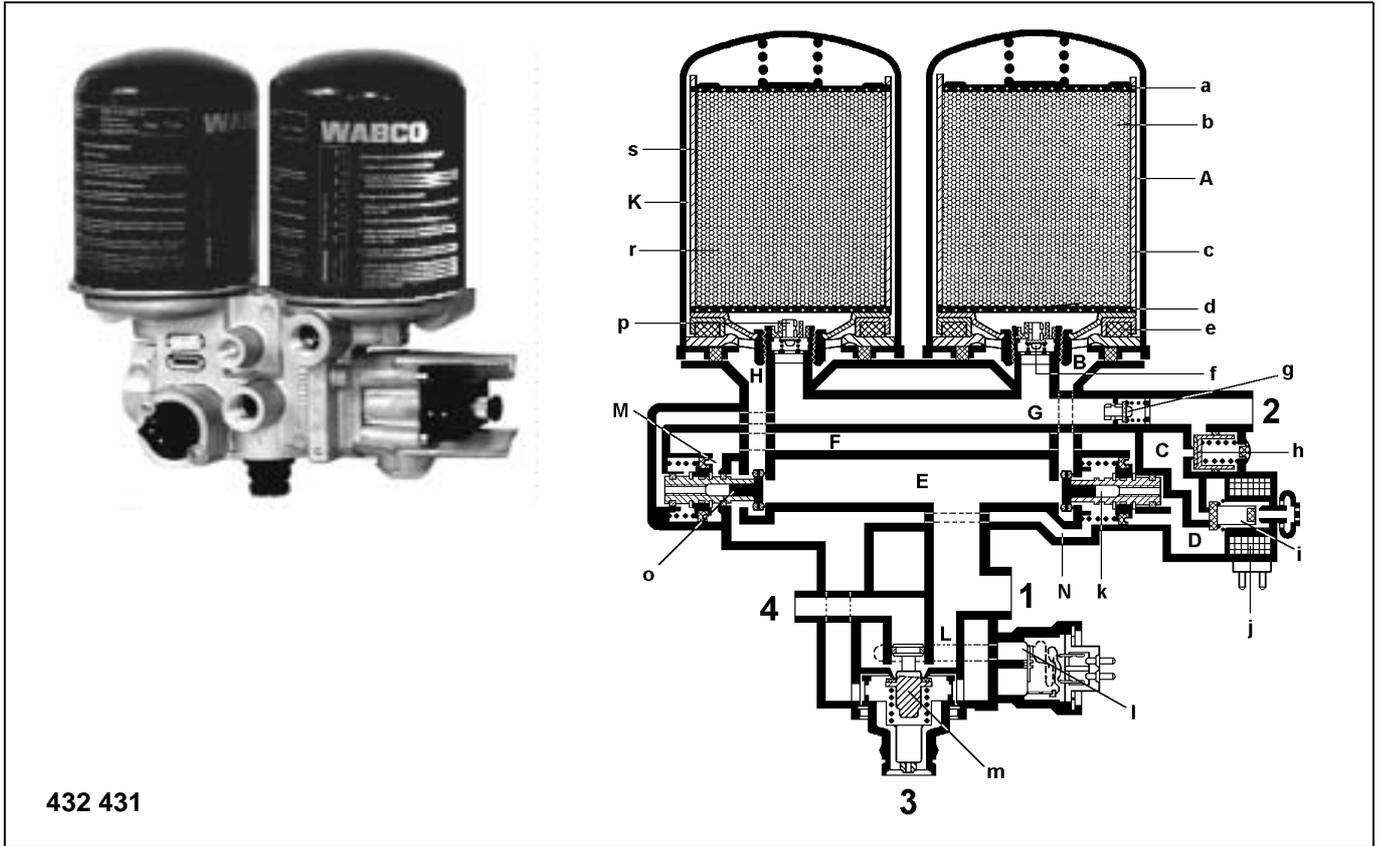
When the cut-in pressure at the unloader is reached, the pressure in Chamber B is reduced once again. The outlet (e) closes and the drying process starts again as described above. Outlet 31 also has a safety valve for the pressure side.

#### Variant 2 (Control Via Integral Unloader Valve 432 415 ... 0)

In this variant, the cut-off pressure reaches Chamber J via the connecting hole into Chamber J and acts on the diaphragm (m). After the spring force has been overcome, the inlet (n) opens and the piston (d) which is now pressurized opens the outlet (e).

The air delivered by the compressor now flows through Chamber A, Duct C and is emitted to atmosphere at Vent 3. The piston (d) at the same time acts as a pop valve. When the pressure is excessive, the piston (d) automatically opens the outlet (e).

If air consumption causes the supply pressure within the system to fall below the cut-in pressure, the inlet (n) closes and the pressure from Chamber B is reduced through the vent of the unloader valve. The outlet (e) closes and the drying process begins again.



432 431

**Twin Chamber Air Dryer  
432 431 . . . 0 and  
432 432 . . . 0**

**Operation:**

**a) Control without Integral Un-loader Valve**

The compressed air supplied by the compressor flows to Bore E via Port 1. Due to a reduction in temperature, condensate may form at Bore E, reaching Idling Control Valve (m) via Bore L. From Bore E, the compressed air will pass Valve (k), enter Chamber B, and reach the upper side of Desiccant Cartridge (c) via Fine Filter (e) integrated into the cartridge, and via Annulus A.

Through Sieve Plate (a), the pre-cleaned compressed air will pass upwards through Granulate (b) sewn into a filter bag in Cartridge (c), reaching Bore G via Sieve Plate (d) and Check Valve (f).

As the air passes through Granulate (b), the inherent moisture is retained by the extremely porous granulate. From Bore G, the compressed air reaches the air reservoirs through Check Valve (g) and via Port 2.

Through the throttling port of Valves (f and p) designed according to the swept volume of the compressor used, part of the dried compressed air from Bore G will reach the underside of Cartridge (s), passing Granulate (r) in an upward direction (backflush). In this process, the moisture adhering to the fine ducts of the extremely porous Granulate (r) is taken up by the dried air and reaches Vent 3 via Annulus K, Chamber H and past the open rear side of Valve (o).

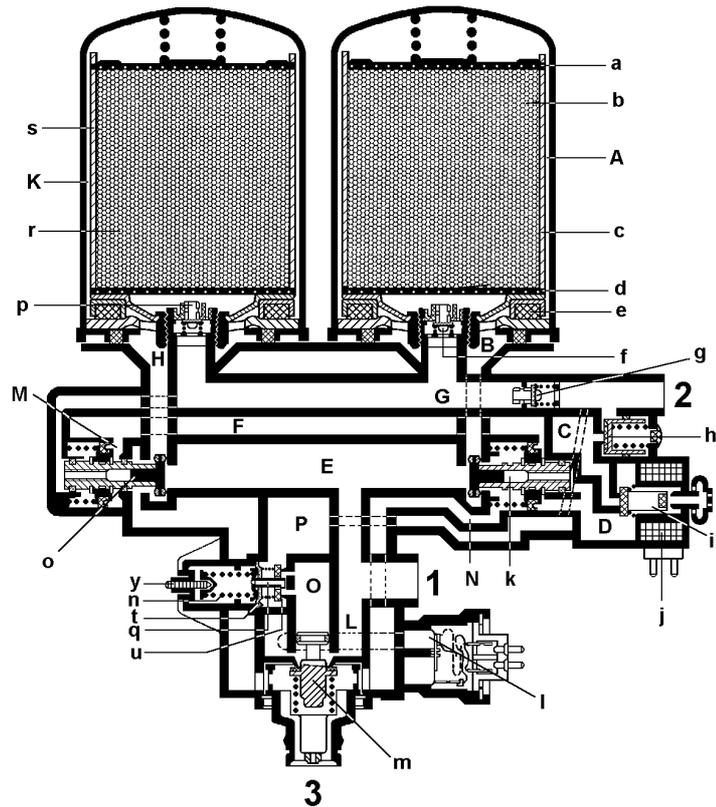
The additional Charging Valve (h) ensures that Control Valves (k and o) do not switch over when the system is filled initially. Valve (h) will not open until a supply pressure of > 5 bar has been reached at Port 2, permitting compressed air to reach Chamber C. If the timeswitch element integrated in the solenoid valve then opens the current supply to Trip Coil (j), Armature (i) will be attracted. Compressed air from Chamber C will now flow into Chamber D and, via Bore F, into Chamber M, moving the control valves against the spring force into their end positions on the left.

The passage from Bore E to Chamber B is closed. The compressed air present in Chamber B will now be emitted at Port 3

after passing by the open rear side of Control Valve (k) and going through Bore N. Check Valve (g) will close and the pressure in the system continues to be ensured. As a consequence of the pressure reduction in Chamber B, Check Valve (f) will also close.

The compressed air supplied by the compressor will now flow from Bore E through Chamber H, Annulus K and through Granulate (r) of Cartridge (s). The drying process of the compressed air is as described before. After Valve (p) and Check Valve (g) have opened, the dried air reaches the reservoirs via Port 2. Through the throttling port of Valve (f), dried air reaches the underside of Granulate (b), causing a back-flushing process to take place here, too.

After approx. 1 minute, the time-switch element will break the current supply to the trip coil. Armature (i) will close the passage from Chamber C, opening the vent, thus reducing the pressure in Chambers D and M. Through the spring force and the pressure in Bore G, the control valves are returned to their end positions on the right. Control Valve (o) will close the passage to Chamber H, and Control Valve (k) will open the pas-



432 432

sage to Chamber B. The compressed air supplied by the compressor is now again fed into Granulate (b), and the drying process will commence as described before, with alternating cartridges continuing to be used at one-minute intervals.

When the unloader valve switches to idling once the input cut-out pressure has been reached, pressure is being fed in at Port 4, pressurizing, and moving downwards, Piston (m), opening the idling control valve. Any condensate and impurities will be emitted together with the air supplied in the idling phase via Vent 3. When the unloader valve switches to load, Port 4 is vented and the idling control valve closes the passage to Vent 3.

Any malfunction due to icing in extreme conditions in the area of Piston (e) can be prevented by fitting a Heating Cartridge (g) which will switch on at temperatures below 6°C and switch off again when the temperature reaches approx. 30°C.

**b) Control Via Integral Unloader Valve**

The air is dried as described under a). The pressure building up at Port 2 when the system is being filled is also present

in Chamber P, pressurizing the underside of Diaphragm (t). As soon as the force resulting therefrom is larger than the force of Pressure Spring (n), Diaphragm (t) will arch, taking with it Piston (q). This opens Inlet (u), and Piston (m), now pressurized, is moved downward, opening the idling control valve. Any condensate and impurities will be emitted together with the air supplied in the idling phase via Vent 3. The compressor will continue to run idle until the pressure within the system has fallen to a value below the unloader valve's cut-in pressure. The pressure in Chamber P below Diaphragm (t) will fall simultaneously. Pressure Spring (n) will move Piston (q) and Diaphragm (t) back to their original positions. Outlet (u) will close, and the pressure from Chamber O will be reduced via the vent of the unloader valve. The idling control valve with Piston (m) will close once again. The compressed air will now again flow into Bore E and reach the air reservoirs via Port 2 after being dried in Desiccant Containers (b or r). The system is subsequently filled once again up to the cut-out pressure of the unloader valve.

**Application:**

Depending on the respective application, WABCO provides Single and Twin Chamber Air Dryers.

The decision of whether to use a Single or a Twin Chamber Air Dryer will depend on the compressor's swept volume and on its duty cycle.

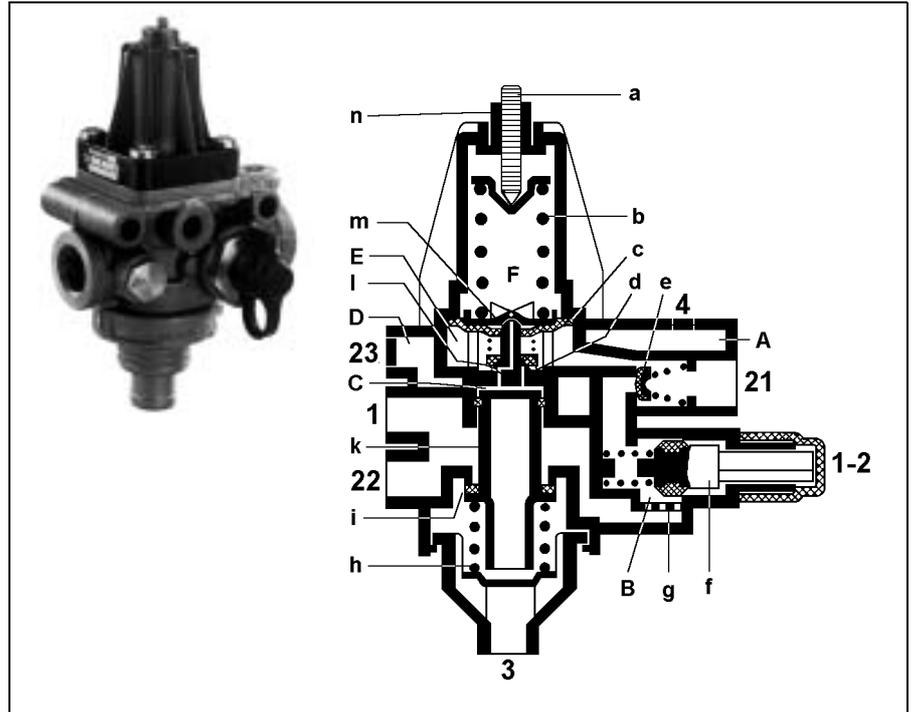
**Single Chamber Air Dryers**

can normally be used for applications up to a swept volume of ≈ 500 litres/minute and a duty cycle of up to ≈ 50%. Any deviations of these standard values should be tested in road-test runs.

**Twin Chamber Air Dryers**

cover the area > 500 litres/minute and > 50% up to 100% duty cycle. Swept volumes in excess of 1000 litres/ minute should be tested in road-test runs

## Combined Unloader 975 303 . . . 0



### Purpose:

To automatically control the operating pressure in an air braking system and to protect its pipes and valves from contamination. Depending on the variant used, it also serves to control a downstream anti-freeze pump or single chamber air dryer.

### Operation:

#### a) Unloader

The compressed air supplied by the compressor flows via Port 1 and Filter (g) to Chamber B. When Check Valve (e) has opened, it flows through the line leading from Port 21 to the air reservoirs and to Chamber E. Port 22 is intended for controlling a downstream anti-freeze pump.

Pressure builds up in Chamber E, acting on the underside of Diaphragm (c). As soon as that pressure is greater than the force of Compression Spring (b), preset by means of Screw (a), diaphragm (c) will arch upward, taking with it Piston (m). Outlet (l) closes and Inlet (d) opens, permitting the compressed air to pass from Chamber E to Chamber C, forcing Piston (k) downwards against the force of Compression Spring (h). Outlet (i) opens and the compressed air supplied by the compressor is released to atmosphere via Exhaust 3. The fall in pressure in Cham-

ber B closes Check Valve (e), thus securing the pressure in the system.

The compressor will now continue to idle until the pressure within the system falls below the Unloader's cut-in pressure. The pressure in Chamber E below Diaphragm (c) continues to fall. This causes the force of Compression Spring (b) to push the diaphragm, together with Piston (m), downwards. Inlet (d) closes, Outlet (l) opens and the air from Chamber C is released to atmosphere at Exhaust 3 after passing Chamber F and a connecting hole. Compression Spring (h) forces up Piston (k) and outlet (i) is closed. The air supplied by the compressor now flows into Chamber B, passing Filter (g), and opens Check Valve (e). The system is once again being filled until the Unloader's cut-off pressure has been reached.

#### b) Unloader with Pilot Connection 4 and Port 23

This type of Unloader differs from the type described under a) merely in the way the cut-off pressure is controlled. The cut-off pressure is not taken from inside the unloader but from the supply line downstream from the air dryer. The passage from Chamber B to Chamber E is closed, and there is no Check Valve (e). Via Port 4 and Chamber A, the air from

the reservoir flows to Chamber E, acting on Diaphragm (c). After that it continues to operate as described under a). The passage between Chambers C and D is open, permitting pilot pressure from Chamber C to be taken at Port 23 to actuate the single chamber air dryer.

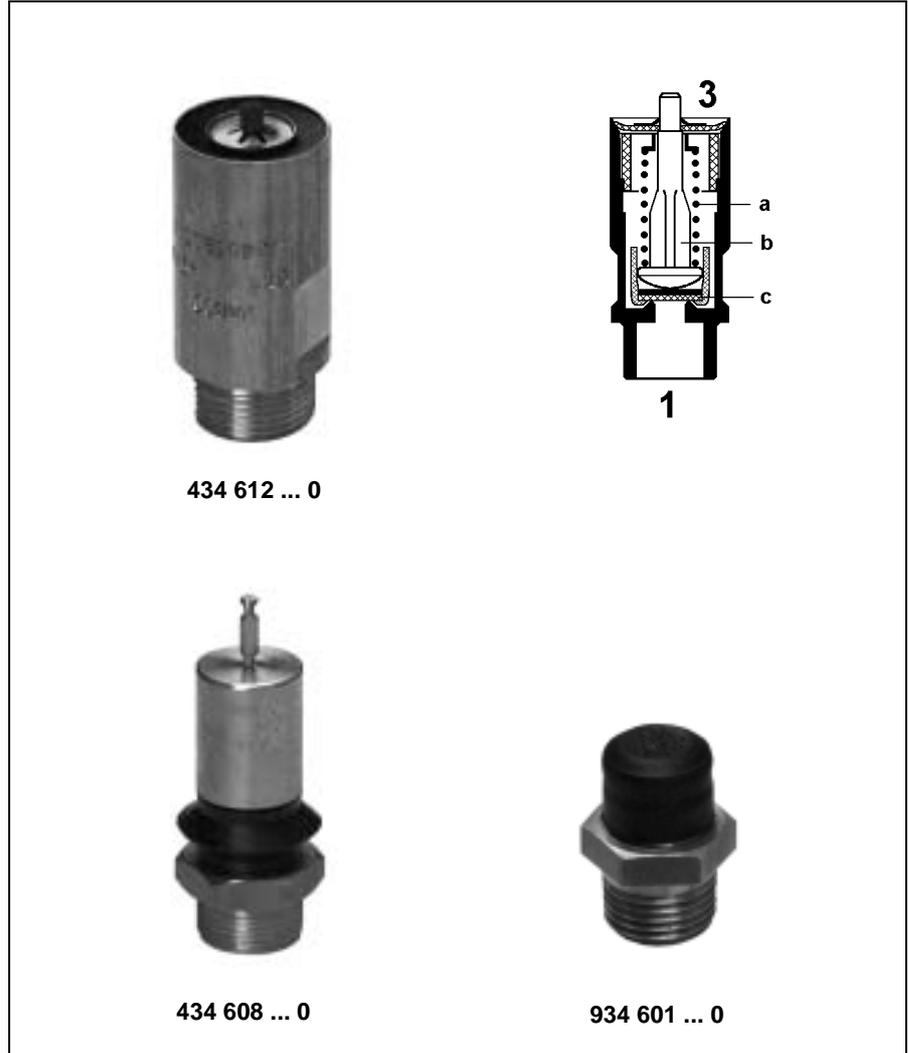
#### c) Tyre inflation connection

After removing the protective cap, the tyre inflation hose is fastened by means of a union nut moving Pin (f). The passage between Chamber B and Port 21 is closed. The air supplied by the compressor now flows from Chamber B to the tyre inflation hose, passing Pin (f). In the event of the pressure in the system exceeding  $12^{+2}$  bar or  $20_{-2}$  bar respectively during this process, Piston (k) which is designed to act as a safety valve will open Outlet (i) and the pressure is released to atmosphere via Exhaust 3.

Before using the tyre inflation facility, the reservoir pressure must be reduced to a value below the Unloader's cut-in pressure since no air can be extracted whilst the compressor is running idle

### Safety Valves

434 6... 0 and  
934 6... 0



#### Purpose:

To limit the pressure within a pneumatic system to the permissible maximum.

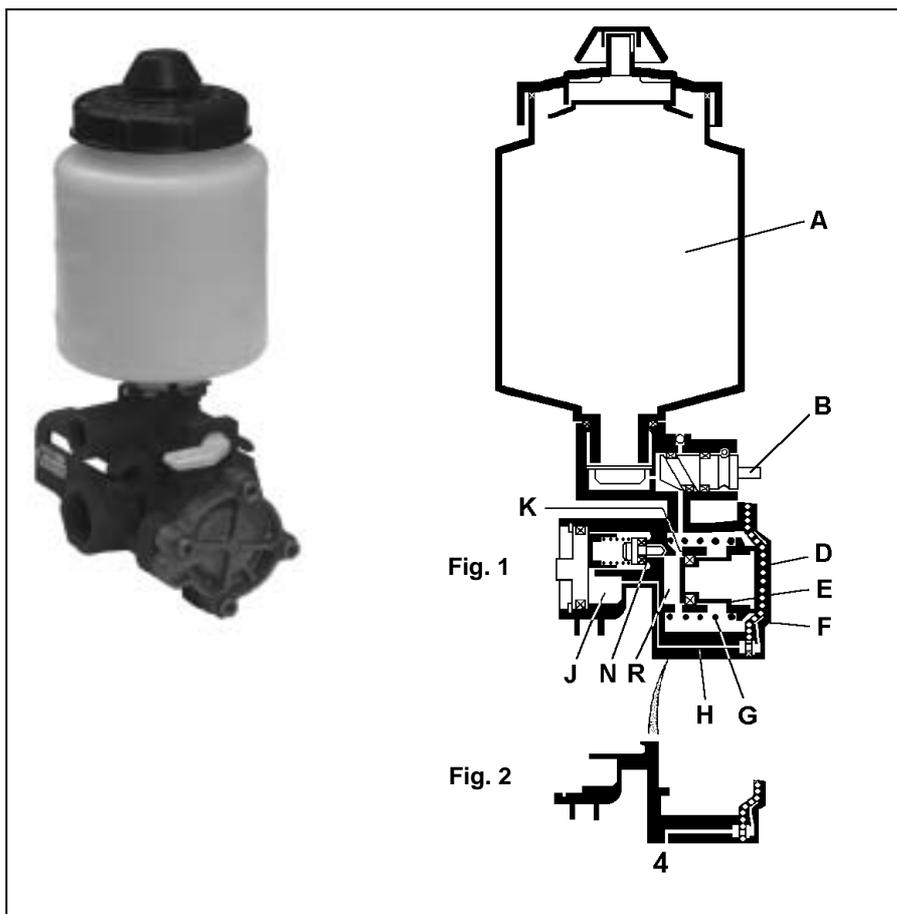
#### Operation:

The compressed air flows through Port 1 and beneath the disk valve (c). When the force resulting from pressure x surface exceeds the preset force of the pressure spring (a), the disk valve (c) is forced upwards with the piston (b). The excess pressure escapes to atmosphere

through Vent 3 until the force of the spring is greater once again and the disk valve (c) closes.

The function of the safety valve can be checked by raising the piston (b).

## Anti-Freeze Pump 932 002 . . . 0



### Purpose:

To automatically inject anti-freeze fluid into the braking system to prevent any moisture present in pipes and its downstream components to freeze.

### Operation:

Depending on the type of anti-freeze pump used, it can be fitted downstream or upstream of the unloader.

Whilst in the anti-freeze pump which is fitted upstream of the unloader the pilot pulse is taken directly from the feed line via an internal hole as the unloader changes from the idle to the load cycle, this pilot pulse has to be taken from a separate line if the anti-freeze pump is fitted downstream of the unloader.

In either case, however, anti-freeze fluid is only injected into the system once the unloader has switched the compressor over to its load cycle, i.e. to supplying compressed air into the system.

### 1. Without a separate pilot connection (Fig. 1)

The compressed air supplied by the compressor flows through the anti-freeze pump from Port 1 to Port 2 (Hole J). The pressure thus building up via Hole (H) in Chamber (F) forces Piston (E) to the left. No anti-freeze fluid can reach Chambers (C) or (R) as Hole (K) is closed. The fluid present in Chamber (R) is displaced by the further movement of Piston (E). It passes Valve Seat (N), reaching Hole (J) and is dispersed in the braking system by the passing stream of air.

Once the operating pressure has been reached in the reservoir, the unloader switches the compressor to idle. The pressure drops in Hole (J) and thus Hole (H) and Chamber (F). Compression Spring (G) returns Piston (E) to its original position. Through the re-opened Hole (K), more anti-freeze fluid flows from its reservoir to Chamber (R).

These processes are repeated every time the unloader actuates the compressor.

### 2. With a separate pilot connection (Fig. 2)

This operates similarly to the processes described under 1. above. With this variant, the actuating pressure is supplied via Port 4 from a separate component, e.g. from the unloader.

### Operation and Maintenance:

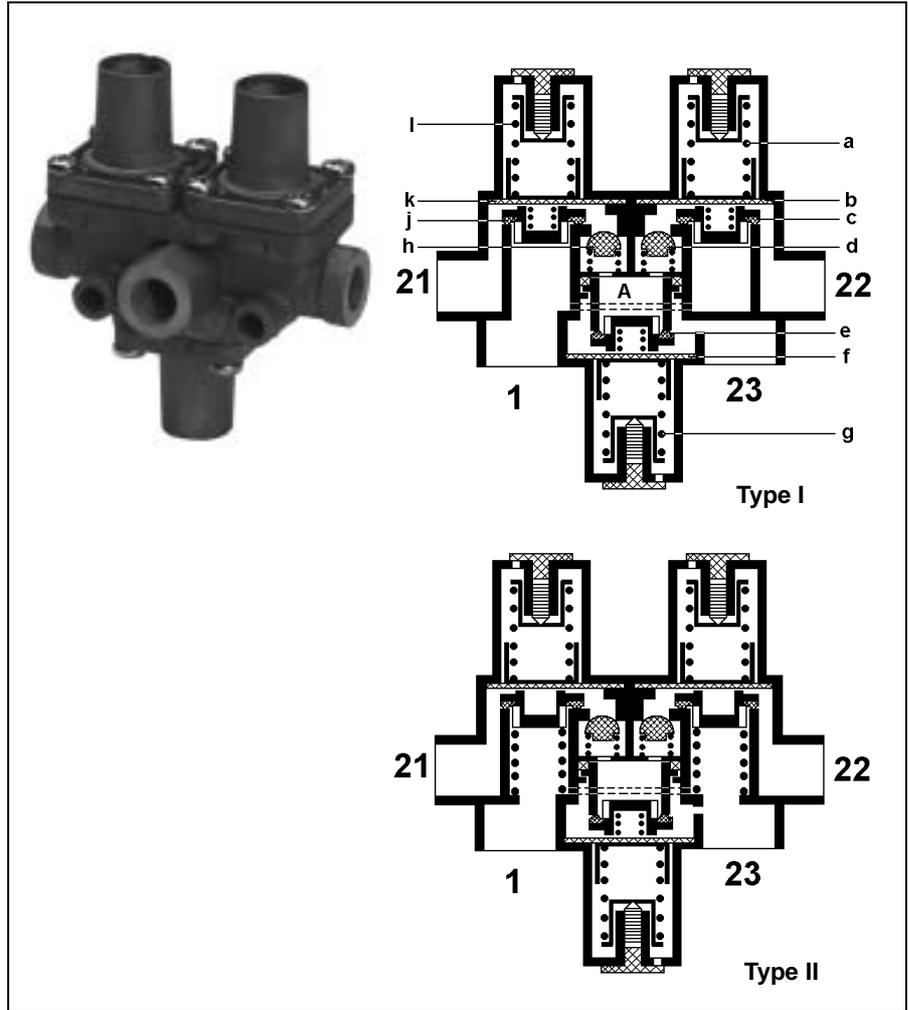
At temperatures below +5°C, the pump needs to be activated by turning Lever (B) to Position I. The level of anti-freeze fluid must be checked daily.

As temperatures rise above +5°C, the pump can be deactivated by turning Lever (B) to Position 0.

During the warm season, the fluid reservoir does not need to be filled. The position of Lever (B) is immaterial.

The anti-freeze pump does not require any special maintenance.

### Three-Circuit Protection Valve 934 701 . . . 0



#### Purpose:

To retain a safe working pressure in the intact circuits of a triple circuit brake system when one circuit has failed.

#### Design:

##### Type I

With all brake circuits intact valves (c and j) are always kept closed, except during the charging operation, by compression spring acting in the closing direction.

##### Type II

By means of the springs acting under the valves (c and j) these valves remain open above a preset opening pressure. In the event of a slight pressure drop in circuits 1 or 2 crossflow from the circuit with the highest pressure, into the other circuits takes place. This reduces the frequency of operation of the unloader.

#### Operation:

Compressed air, passing from the unloader valve through port 1 into the triple protection valve, opens the valves (c and

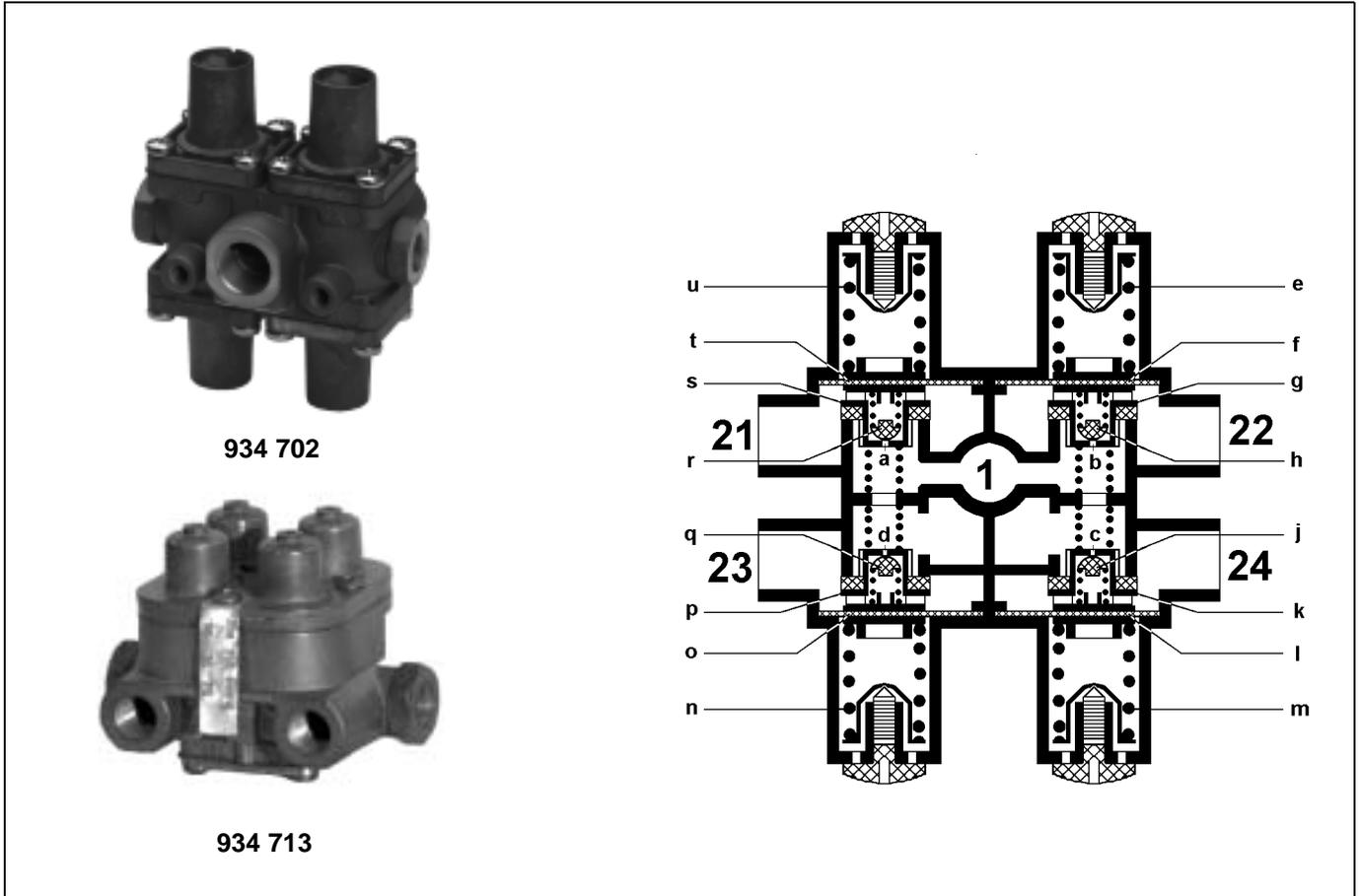
j) after the preset opening pressure (protection pressure) has been reached, raising the diaphragms (b and k) against the action of the pressure springs (a and l). The compressed air then flows through ports 21 and 22 into the air reservoirs of circuits 1 and 2. It also passes into chamber (A) after the non-return valves (d and h) have opened, opens valve (e) and flows through port 23 into circuit 3. From circuit 3 the auxiliary and parking brake equipment of both the motor vehicle and the trailer are supplied with air.

If for example circuit 1 fails because of a leak, the compressed air still being supplied from the unloader, first passes into the leaking circuit. But as soon as a pressure drop occurs in circuits 2 or 3 after application of the brakes, valve (j) closes because of the pressure spring (l) and the intact circuit under load, is refilled until the opening pressure of the valve (j) is reached. This refilling can occur because the pressure remaining in the intact circuits after any application of the brakes

exerts a counter-force on pressure spring (a or g) through diaphragm (b or f). Thus valve (c or e as the case may be) can still open even though the opening pressure for valve (j) has not yet been reached. Pressure protection for circuits I and III works in exactly the same way in the event of failure of circuit II.

In the event of failure of the auxiliary brake circuit, a crossflow of air from the reservoirs of circuits 1 and 2 into circuit 3 occurs until valve (e) can no longer be kept open by the falling crossflow pressure, and it closes when the preset opening pressure is reached. The pressures in the two main brake circuits remain safeguarded to the level of the opening pressure for the defective circuit 3.

In the event of failure of circuit 1 or 2 below the opening pressure of the valves (c or j respectively), the non-return valves (d and h) protect the intact circuit from the failed circuit.



## Four-Circuit Protection Valves

934 702 . . . 0

934 713 . . . 0 / 934 714 . . . 0

### Purpose:

Retention of pressure in the intact braking circuits in case of failure of one or more circuits in a four-circuit air-braking system.

### Operation:

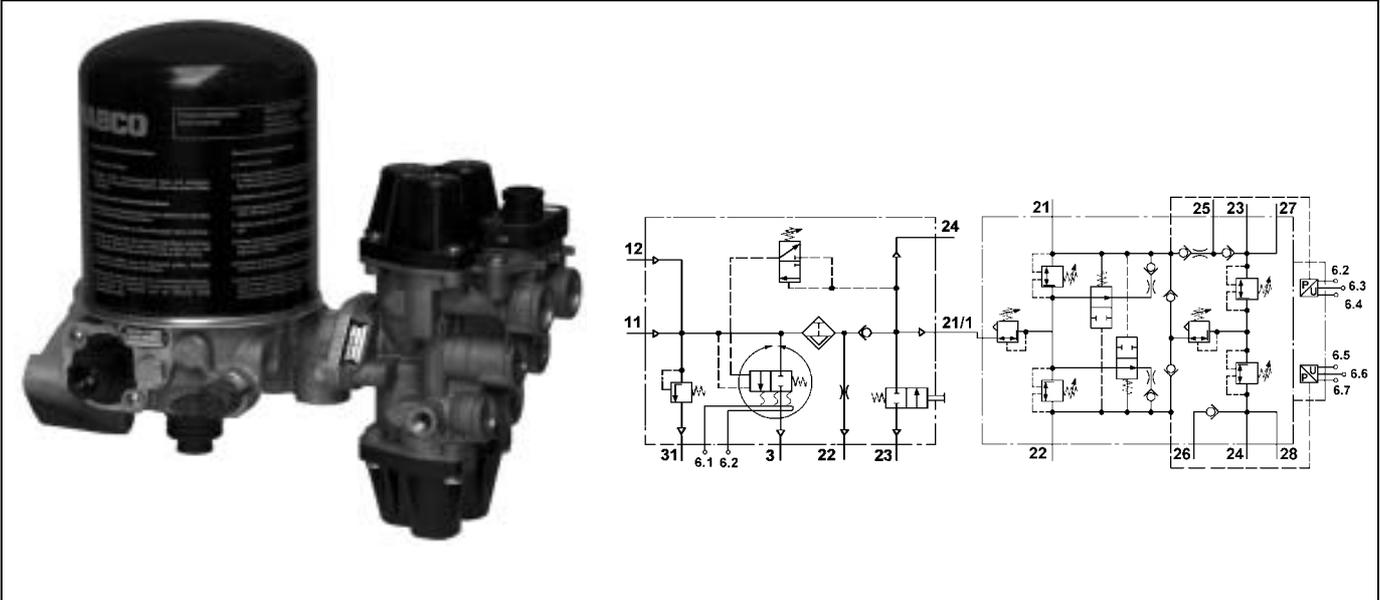
Depending on the variant used, the four circuits are connected in parallel and all four circuits are filled equally, or Circuits 3 and 4 are secondary to Circuits 1 and 2. The quadruple-circuit protection valve may, depending on the variant, have bypass holes in all circuits which ensure that the braking system is filled from 0 bar should one circuit fail.

Compressed air flows from the unloader valve through port 1 into the protection valve and through by-pass bores (a, b, c, and d). It continues through check valves (h, j, q and r) into the four circuits of the

system. Simultaneously, pressure builds up below valves (g, k, p and s), opening the valves after reaching the set opening pressure (protection pressure). Also, diaphragms (f, l, o and t) are raised against the force of compression springs (e, m, n and u). Compressed air then flows through ports 21 and 22, to circuit 1 and 2 air reservoirs of the service brake system, and through ports 23 and 24 into circuits 3 and 4. Circuit 3 supplies compressed air to the emergency and parking brake system of the truck and to the trailer supply line; circuit 4 supplies the auxiliary systems.

If one of the service brake circuits (e.g. circuit 1) fails, air flows from the other three circuits into the failed circuit until the dynamic valve closing pressure is reached. The force of compression springs (e, m, n and u) causes valves (g, k, p and s) to close. If air is consumed in circuits 2, 3, or 4, refilling will occur to the level of the set opening pressure of the failed circuit. Pressure protection of the intact circuits takes place in the same way if another circuit fails.

If one circuit (e.g. circuit 1) fails, and in addition, for any reason the pressure drops to zero bar within the intact circuits, then, when the brake system refills, compressed air flows initially through bypass bores (a, b, c and d) into all four circuits. The resulting pressure build-up below the diaphragms (f, l and o) of the intact circuits decreases the opening pressure of valves (g, k and p). Further pressure increase in port 1 causes valves (g, k and p) to open. Intact circuits 2, 3 and 4 are refilled to the level of the set opening pressure of failed circuit 1 and are protected at that level.



## APU - Air Processing Unit 932 500 . . . 0

### Description:

The APU (Air Processing Unit) is multi-functional, i. e. it is a combination of several types of equipment. It includes an air dryer with an unloader valve, with or without heating, depending on the variant, a safety valve and a tyre inflation connector. A multiple-circuit protection valve with one or two integrated pressure limited valves and two integrated check valves is flanged to the air dryer.

Some versions also have a double pressure sensor mounted on the multiple-circuit protection valve for measuring the supply pressures in the service braking circuits.

### Purpose:

The air dryer is used to dry and cleanse the compressed air delivered by the compressor, and to control the supply pressure. The flanged multiple-circuit protection valve is used to limit and guard the pressure in multiple-circuit braking systems.

### Operation:

The compressed air delivered by the compressor enters at Port 11 and passes

a filter before reaching the granulate cartridge. As it flows through the granulate, the air is filtered and dried (please refer to Air Dryer 432 410 ... 0 on Page 11). The dried air then flows through Port 21 to Supply Port 1 of the flanged multiple-circuit protection valve. When the level of supply pressure has been reached, the integrated unloader valve actuates the idle valve and the compressor now delivers to atmosphere. In the idle phase, the granulate is regenerated in the return flow via Port 22 with dried and non-compressed air.

The air dryer includes a safety valve which opens if the pressure becomes excessive. To prevent functional defects of the idle valve in winter, a heating system has been integrated. The tyre inflation connector or Port 12 can be used to fill the system externally (workshop). The air reservoirs for air suspension are connected to Port 24.

In a first step, the pressure at Supply Port 1 ( $10 \pm 0.2$  bar) of the multiple-circuit protection valve is reduced to the level required for the service braking systems, and in a second step ( $8.5 \begin{smallmatrix} 0 \\ -0.4 \end{smallmatrix}$  bar) to the level required for the trailer's braking system.

In the event of one circuit failing, the

pressure in the other circuits will initially fall to the dynamic closing pressure (due to the trailer) but will then rise again until it reaches the opening pressure ( $9.0 \begin{smallmatrix} 0 \\ -0.3 \end{smallmatrix}$  bar Circuits 1 + 2 and  $7.5 \begin{smallmatrix} 0 \\ -0.3 \end{smallmatrix}$  bar Circuits 3 + 4) of the defective circuit (= secured pressure). This requires the compressor to be running and to deliver more compressed air. If this pressure is exceeded, the air delivered will escape into the defective circuit and thus be evacuated to atmosphere.

An electronic pressure sensor unit permits the continuous display of the pressures in the service braking circuits. In addition, Circuits 3 and 4 have outputs (25 and 26) secured by one check valve each.

When pressurizing the braking system starting at 0 bar, the service braking circuits (1 and 2) are filled first in keeping with EC guideline 71/320/EEC.

## Air Reservoir 950 . . . . . 0



### Purpose:

Storage of the compressed air delivered from the compressor.

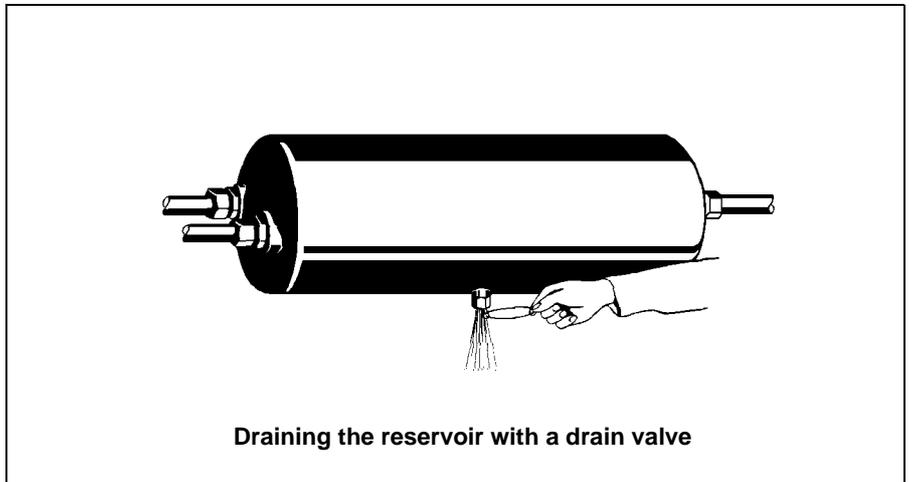
### Construction:

The reservoir consists of the cylindrical portion in the centre with welded-in arched bases and screw necks for connecting pipes. The use of high-tensile steels of even material thickness for all air reservoir sizes permits operating pressures in excess of 10 bar in air reservoirs of volumes below 60 litres.

The reference plate is glued on and must, in keeping with EN 286: 2, contain the following data: number and date of the standard, manufacturer's name, serial number, modifications, the manufacturing date, the licence number, the volume in litres, permissible operating

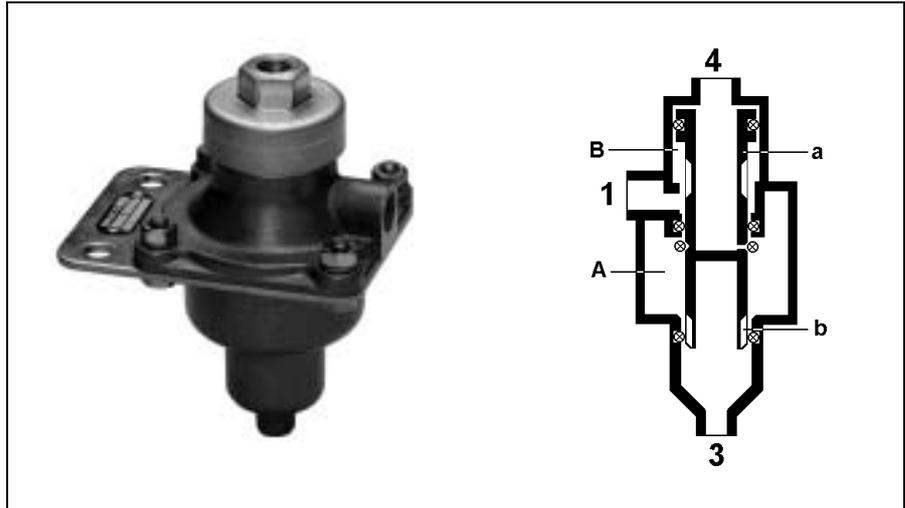
pressure, minimum and maximum operating temperatures, the CE symbol if in accordance with 87/404/EC. The name plate is covered with a sticker showing the WABCO part number. In the event of the air reservoir having been painted by the vehicle manufacturer, that sticker must be removed to make the actual reference plate become visible.

The air reservoir should be drained regularly to remove any condensate. It is advisable to use drain valves which are available for both manual and automatic actuation. Regularly check the mounting on the frame and the clamp clips.



Draining the reservoir with a drain valve

### Automatic Drain Valve 434 300 . . . 0



**Purpose:**

It prevents the accumulation of water in pipe lines and brake chambers through automatically draining the reservoirs.

**Operation:**

Air from the auxiliary port on the unloader enters the control port 4 and pushes the piston (a) to its lowest position. Water from the reservoir enters port 1 and passes into chamber (A) via the undercut diameter on piston (a).

Water in the control line passes into chamber (A) via the small hole in the piston (a).

As the unloader cuts-out, the pressure in the control line falls to zero, and the pressure in the reservoir pushes the piston (a) to its uppermost position, and the water is ejected via the undercut diameter (b).

The O-ring check valve covering the small hole in piston (a) prevents water and reservoir air in chamber (A) from entering the control line - (which might occur during that last few revolutions of the compressor when the vehicle engine is switched off, if it were not for the O-ring).

### Drain Valve 934 300 . . . 0



**Purpose:**

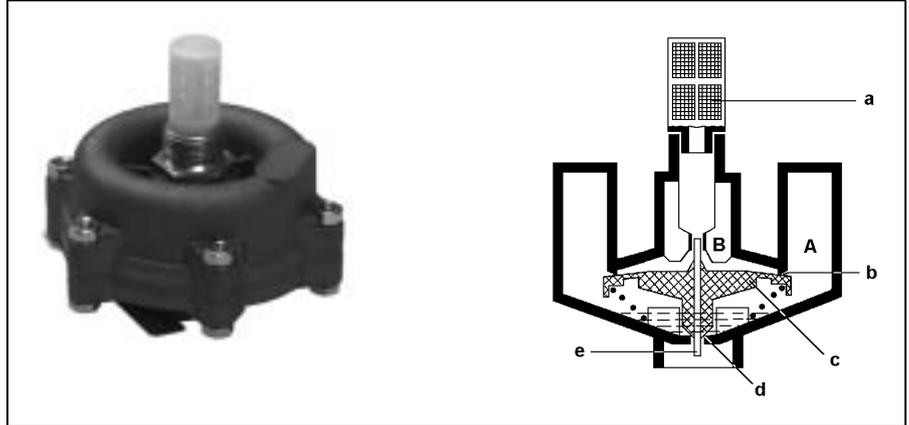
To drain condensation water from the air reservoir and, if necessary, to exhaust the compressed air lines and reservoirs.

**Operation:**

Valve (b) is held closed by spring (a) and

by pressure in the reservoir. Pulling or pushing actuating pin (c) in a lateral direction opens tilting valve (b). This permits both compressed air and condensation water to escape from the reservoir. On releasing actuating pin (c), valve (b) closes

## Automatic Drain Valve 934 301 . . . 0



### Purpose:

Protection of the compressed-air equipment from ingress of condensate by means of automatic draining of the air reservoir.

### Operation:

When the air reservoir is filled, compressed air passes through filter (a) in chamber (B) on to the valve diaphragm (c). This lifts off the inlet (b) on its outer periphery. Compressed air flows together with accumulated condensate, if any, out of the air reservoir into chamber (A), where the condensate accumulates above the outlet (d). After pressure equilibrium is established between the two chambers the valve diaphragm (c) closes the inlet (b).

If, because of a braking action, for example, the pressure in the air reservoir falls, the pressure in the chamber (B) is reduced, while in chamber (A) the full pressure is at first maintained. The higher pressure in chamber (A) acts from below on the insert (c) and lifts it off the outlet (d). The condensate is forced out by the air cushion in chamber (A). When the pressure in chamber (A) has fallen far enough to establish a pressure equilibrium between chamber (B) and (A) again, the insert (c) closes the outlet (d).

To check the function of the drain valve the outlet can be opened manually by pressing inwards the pin (e) seated in the outlet.

## Air Pressure Gauges 453 . . . . . 0



### Purpose:

Air pressure gauges are used to monitor the pressure in air reservoirs and brake lines.

### Operation:

In the single air pressure gauge 453 002, the pressure from the reservoir stretches the tube spring which, via a lever and rack, moves the pointer which is mounted on a pivot shaft.

In the case of a drop in pressure the pointer is returned to the reading of re-

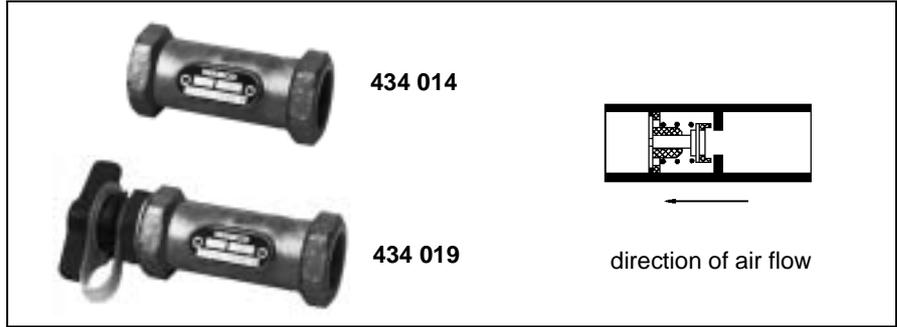
maintaining pressure by means of a torsion spring.

In the double air pressure gauge 453 197, a further red pointer indicates the pressure of air entering the brake chambers when brakes are applied. When brakes are released, a torsion spring returns this red pointer to the zero position. Reservoir and service pressure readings are divided into 0 to 10 and 0 to 25 bars respectively.

# 1.

## Check Valves

### Check Valve 434 01... 0



**Purpose:**

To protect the pressurized lines against unintentional venting.

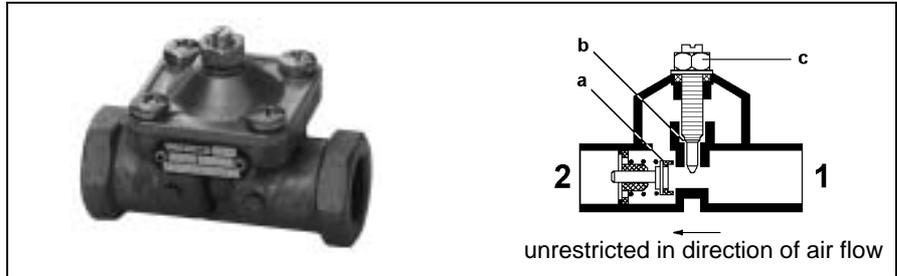
inlet in the event of a drop in pressure in the supply line.

**Operation:**

Air can only pass in the direction indicated by the arrow. Return flow of the air is prevented by the check valve closing the

When the pressure rises in the supply line, the springloaded check valve again opens the passage which results in an equalization of pressure.

### Check-Choke Valve 434 015... 0



**Purpose:**

To restrict the air flow, optionally when the connected line is pressurized or depressurized.

Port 2 is vented through the throttling port (b). The cross-section of the throttle can be adjusted using the adjuster screw (c). Turning it clockwise will reduce the cross-section, thus retarding the venting process, and turning it anti-clockwise will increase the cross-section.

**Operation:**

As the air enters in the direction indicated by the arrow, the check valve (a) fitted in the housing is raised off its seat and the connected pipe is pressurized with no restriction. When the feed pipe is pressurized, the check valve closes and

By connecting the air-supply against the direction indicated by the arrow, pressurizing can be throttled, and venting can be unrestricted.

### Check Valve 434 021... 0



**Purpose:**

To make sure that the pressure in air reservoirs is not unintentionally decreased.

the feed pipe and the reservoir are equal.

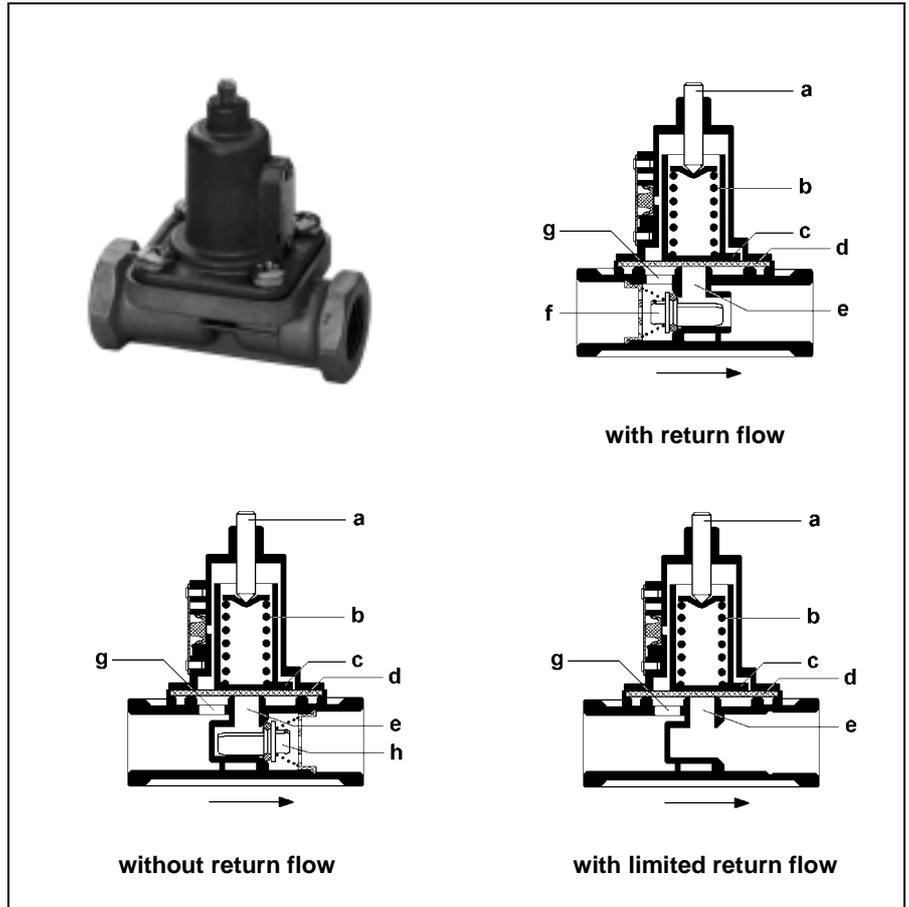
**Operation:**

The compressed air from the feed pipe opens Valve (a) and reaches the air reservoir provided its pressure is higher than that within the reservoir. Valve (a) will remain open until the pressures in

Valve (a) prevents the air from returning from the reservoir as, when the pressure in the feed pipe is reduced, the valve is closed by Compression Spring (b) and the higher reservoir pressure.

Air can pass through the check valve only in the direction from the feed pipe towards the reservoir.

## Charging Valve 434 100 . . . 0



### Purpose:

#### Charging Valve with return flow

The passing of compressed air to second air brake reservoir only when the rated pressure for the system in the first reservoir has been reached. If the pressure in the first reservoir falls below that of the second reservoir there is a feedback supply of air from the second reservoir.

#### Charging Valve without return flow

The passing of compressed air to auxiliary equipment (e. g. door actuation, auxiliary and parking braking systems, servo clutch, etc.) only when the rated pressure for the braking system has been reached in every air reservoir.

#### Charging Valve with limited return flow

The passing of compressed air to other consumers (e. g. auxiliary and parking braking systems) only when the rated pressure for the braking system has been reached in all reservoirs. Also the protection of pressure for the motor vehi-

cle in the event of the trailer's supply line failing.

If the pressure in the air reservoirs of the service braking system drops, part of the compressed air will return until the closing pressure (which is dependent on the opening pressure) is reached

### Operation:

With all charging valves, the compressed air passes in the direction of the arrow into the housing and through port (g) under diaphragm (d) which is pressed into its seat by adjusting spring (b) and piston (c). When the charging pressure has been reached, the force of the adjusting spring (b) is overcome so that the diaphragm (d) is lifted from its seat, opening port (e). The air flows directly or after opening of non-return valve (h) to the reservoirs or consumers in the direction of the arrow.

Charging valves with return flow allow the compressed air to flow back from the

second reservoir after the opening of check valve (f) if the pressure in the first reservoir has dropped by more than 0.1 bar.

In the case of charging valves without return flow, return flow is not possible since non-return valve (h) is kept closed by the higher pressure in the second reservoir.

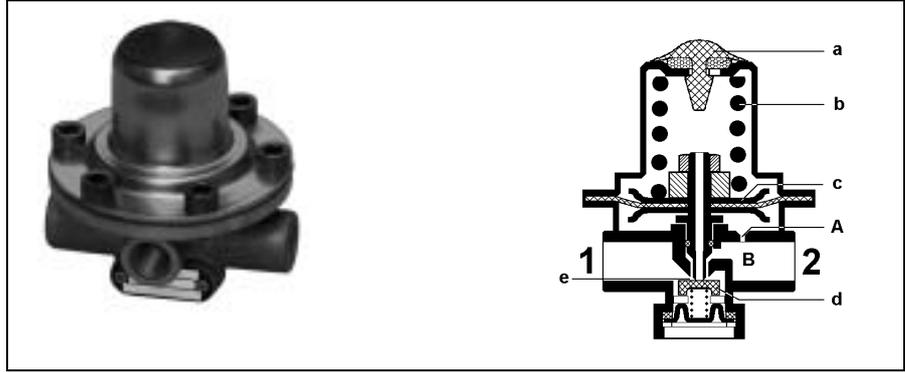
Charging valves with limited return flow allow the air to flow back until the closing pressure of diaphragm (d) is reached. When this is reached, adjusting spring (b) presses diaphragm (d) into its seat via piston (c), thus preventing any further pressure compensation in the direction opposite to the direction of the arrow.

The charging pressure can be adjusted on all types by turning adjusting screw (a). Turning clockwise increases charging pressure, turning anti-clockwise has the opposite effect.

# 1.

## Pressure Limiting Valves

### Pressure Limiting Valve 475 009 . . . 0



#### Purpose:

To limit the output pressure.

#### Operation:

The compressed air from the high-pressure side, Port 1, flows through the inlet (e) and Chamber B to the low-pressure Port 2. This also causes the diaphragm piston (c) to be pressurized through Hole A although this is initially being held in its lower position by the pressure spring (b).

When the pressure in Chamber B reaches the level set for the low-pressure side, the diaphragm piston (c) overcomes the

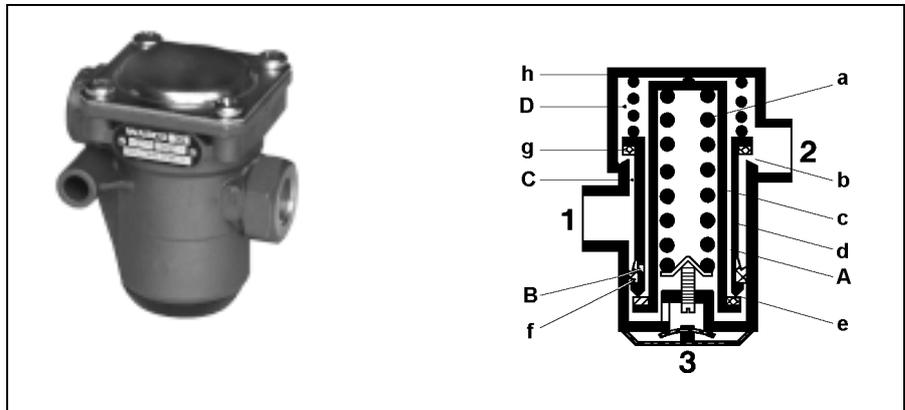
force of the pressure spring (b) and moves upwards, together with the spring-loaded valve (d), closing the inlet (e).

When the pressure in Chamber B has risen above the preset value, the diaphragm piston (c) continues to move upwards and is raised off the valve (d). The excess pressure escapes to atmosphere through the drill hole in the piston rod of the diaphragm piston (c) and the vent valve (a).

In the event of any leakage in the low-pressure line, Port 2, causing a loss in pressure, the force acting on the dia-

phragm piston (c) falls and causes it to move downwards, opening the valve (d). An amount of compressed air equalling the amount of pressure lost is now fed in through the inlet (e). When the pressure in the high-pressure line is reduced, the pressure in Chamber B which is now higher will initially open the inlet (e) of the valve (d). Due to the drop in pressure beneath the diaphragm piston (c), this piston will move downwards, keeping the valve (d) open. The pressure in the low-pressure line is reduced by the valve connected with the high-pressure side.

### Pressure Limiting Valve 475 015 . . . 0



#### Purpose:

To limit the output pressure to a preset value.

#### Operation:

The Pressure Limiting Valve is set in such a way that its output pressure on the low-pressure side (Port 2) is limited. Spring (a) constantly acts on Pistons (c and d), holding Piston (c) in its upper end position where it is in contact with Housing (h). Inlet (b) is open. The supply air flows from Port 1 to Chamber C and on to Chamber D, reaching the downstream components via Port 2.

When the pressure building up in Cham-

ber D exceeds the force of Compression Spring (a), Pistons (c and d) are forced downwards. Valve (g) closes Inlet (b) and an end position has been reached.

As air is consumed at the low-pressure side, the pressures at Piston (c) are no longer balanced. Spring (a) will force Pistons (c and d) upwards once again. Inlet (b) opens and more air is supplied until the pressure has reached the preset value and the pressures are once again balanced.

In the event of the pressure on the low-pressure side exceeding the present value, Piston (c) which is designed as a

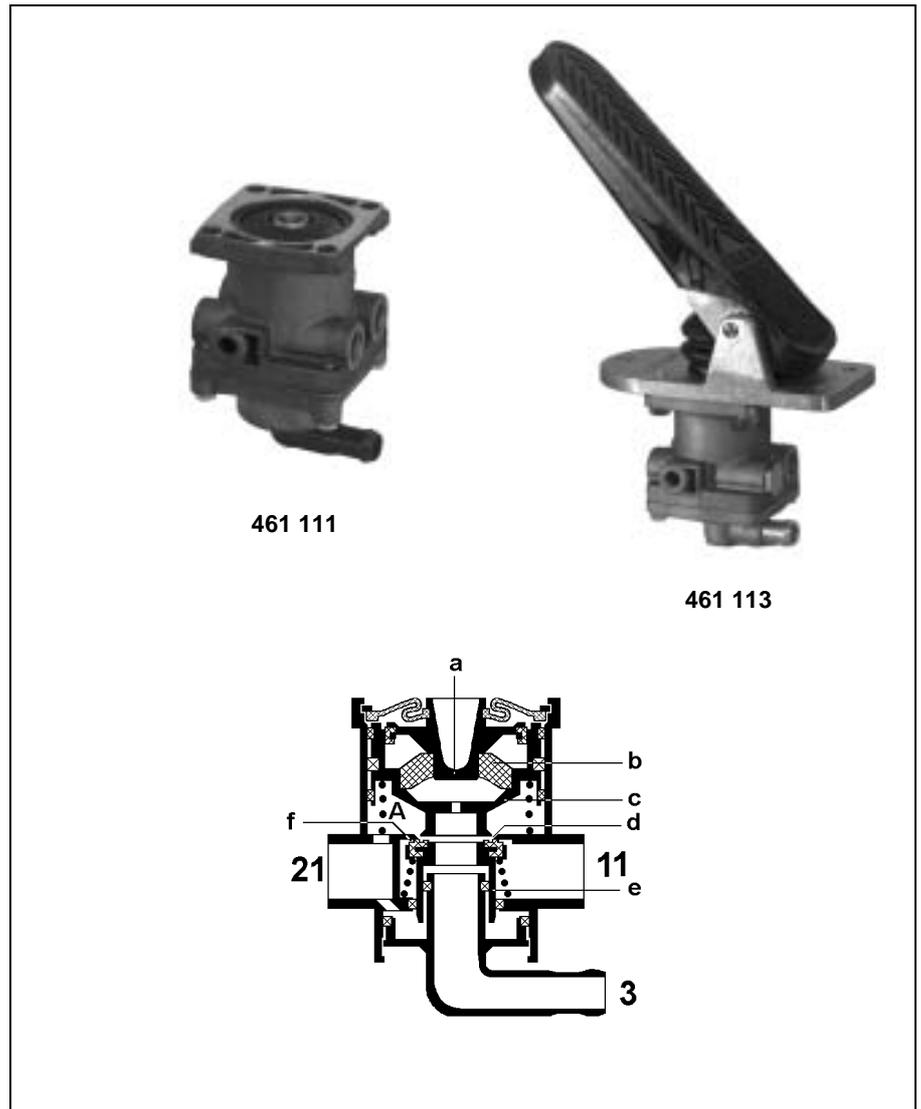
safety valve will open Outlet (e). The excess pressure will be released to atmosphere via Exhaust 3.

If the pressure in Chamber C falls below that in Chamber D, Valve (f) will be opened. The compressed air from Chamber D will now return through Hole B to Port 1 until the force of Spring (a) is greater once more, opening Inlet (b). The pressures between Ports 2 and 1 are balanced.

#### Please note:

The 475 010 ... 0 range of pressure limiting valves (see Page 71) is also used on the motor vehicle.

**Brake Valve  
For Single-Circuit Braking  
Systems  
461 111 ... 0  
With Treadle  
461 113 ... 0**



**Purpose:**

Sensitive increase and decrease in the pressure of the single-circuit service braking system of a motor vehicle.

**Operation:**

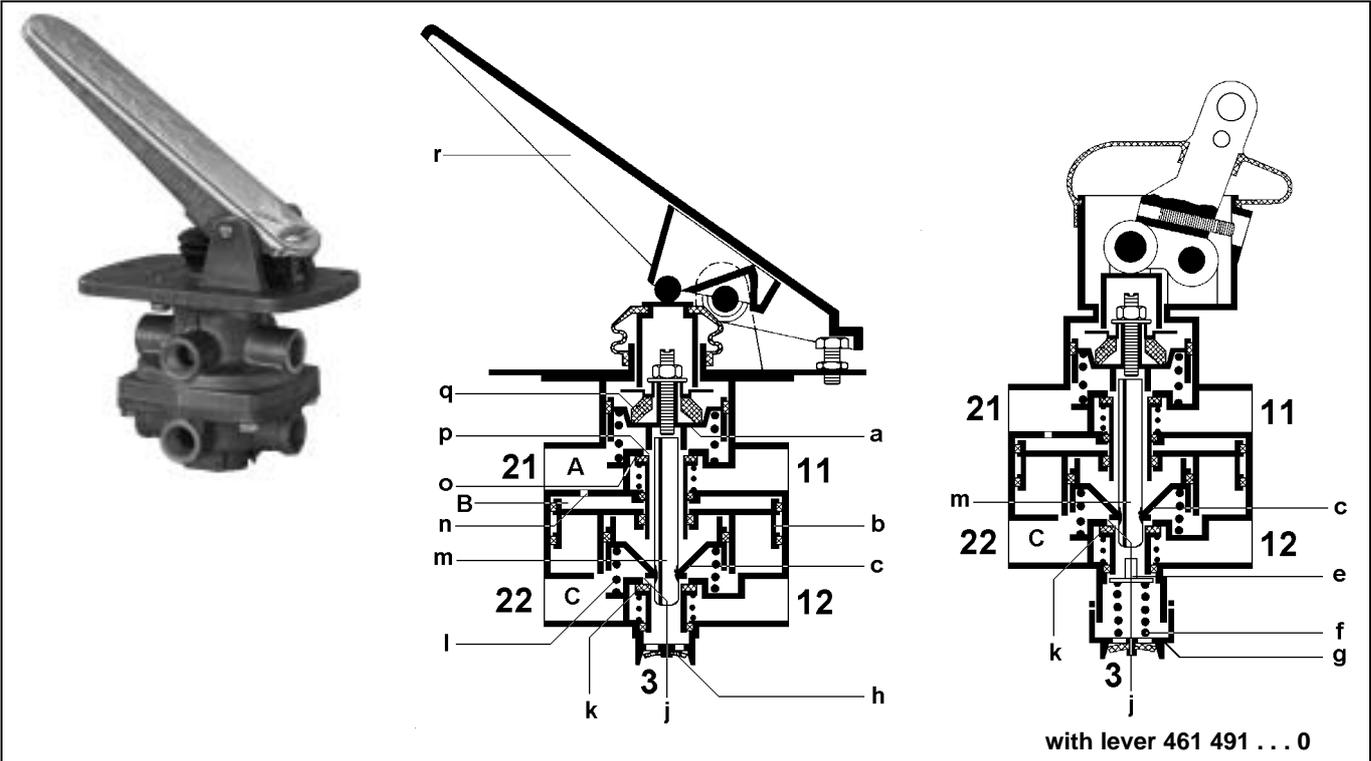
When the plunger in the spring plate (a) is actuated, the piston (c) moves downward, closing the outlet (d) and opening the inlet (e). The air supply at Port 11 flows through Chamber A and Port 21 to the downstream braking equipment of the service braking circuit.

The pressure building up in Chamber A acts on the underside of the piston (c). This is forced upwards against the force of the rubber spring (b) until the force acting on both sides of the piston is balanced. In this position, both the inlet (e)

and the outlet (d) are closed, and a neutral position has been reached.

At full brake application, the piston (c) is moved to its lower neutral position, and the inlet (e) remains open.

When the pressure in the service braking circuit is to be decreased, this process is reversed and can also be achieved gradually. The pressure in Chamber A forces the piston (c) upwards. The pressure in the service braking system is now reduced partially or fully, depending on the position of the plunger, through opening the outlet (f) and Vent 3.



## Brake Valve With Treadle 461 307... 0

### Purpose:

Sensitive increase and decrease in the pressure of the twin-circuit service braking system of a motor vehicle.

### Operation:

When the treadle (r) is pushed down, the graduating piston (a) moves downwards, closing outlet (p) and opening inlet (o). This causes total or partial increase in the pressure for the brake cylinders of the first circuit and the trailer control valve from supply port 11 via port 21, depending on the amount of force applied.

In this process, the pressure in Chamber A will initially build up beneath the graduating piston (a) and also, through the hole (n), in Chamber B, acting on the relay piston (b) of the second circuit. The relay piston (b) is forced downwards against the force of the spring (l), taking with it piston (c). This also causes outlet (j) to be closed and inlet (k) to be opened. Compressed air flows from 12 via Port 22 into the brake cylinders of the second circuit which are pressurized according to the controlling pressure in Chamber B.

Because of the force of the spring (l), the pressure in Chamber C is always slightly

lower than that in Chambers A and B.

The pressure building up in Chamber A also acts on the underside of the graduating piston (a) which is thus forced upwards against the force of the rubber spring (q) until the forces on both sides of the piston (a) are balanced. In this position, inlet (o) and outlet (p) are closed (neutral position).

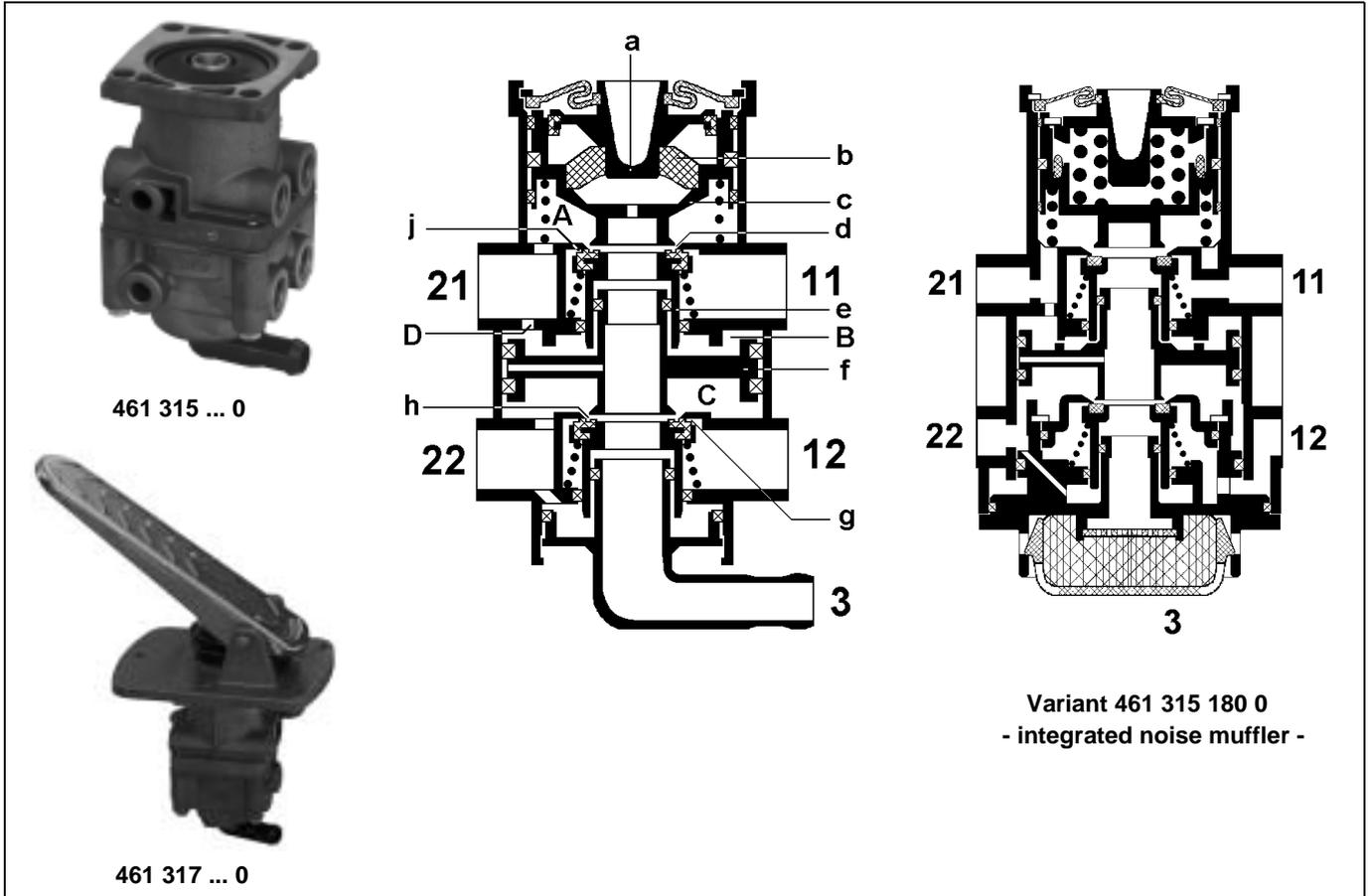
Similarly, as the pressure is increased in Chamber C, acting on the underside of the pistons (b) and (c), together with the spring (l), these pistons are forced upwards until they have also reached their neutral position, i. e. until inlet (k) and outlet (j) are closed.

When the brakes are fully actuated, the piston (a) is moved into its lower neutral position and inlet (o) remains open. The full pressure now present in Chamber B forces the relay piston (b) into its lower neutral position, and piston (c) keeps inlet (k) open. The full amount of air supply flows into both service braking circuits.

When the brakes are released, i. e. the pressure in both circuits is decreased, this process is reversed and can also be achieved gradually. The pressure in both circuits is reduced through the release valve (h).

In the event of Circuit II failing, Circuit I continues to operate as described. Should Circuit I fail, the relay piston (b) is no longer actuated; Circuit II then works mechanically as follows: When the brakes are actuated, piston (a) is forced downward. As soon as it makes contact with the insert (m) which is firmly connected to piston (c), this piston (c) is also pushed downward in the course of its downward stroke; outlet (j) closes and inlet (k) opens. Thus Circuit II continues to be fully operational even if Circuit I has failed since piston (c) now operates as a graduating piston.

Different variants of the brake valve have an additional feature allowing the infinitely variable adjustment, within a certain range, of the predominance of Circuit I over Circuit II by means of pressure retention in Circuit II. For this purpose, the initial tension of the spring (f) is altered by means of turning the cap (g). As piston (c) moves downwards, the insert (m) connected to it will first make contact with the spring-loaded plunger (e) before closing outlet (j) and opening inlet (k). The preset initial spring tension now determines which pressure in Chamber C will move the piston (c) upward off the plunger (e) to reach its neutral position.



**Brake Valve**  
**461 315 ... 0**  
**With Treadle**  
**461 317 ... 0**

**Purpose:**

Sensitive increase and decrease in the pressure of the twin-circuit service braking system of a motor vehicle. Some variants from the 461 315 ... 0 series have an integrated noise muffler to reduce the space required for installing the valve.

**Operation:**

When the plunger in the spring plate (a) is actuated, piston (c) moves downward, closing outlet (d) and opening inlet (j). The air supply at Port 11 flows through Chamber A and Port 21 to the downstream braking equipment of service braking circuit I. At the same time, compressed air flows via Hole D into Chamber B, acting on the upper side of piston (f) which is forced downward, closing outlet (h) and opening inlet (g). The air

from Port 12 flows through Chamber C and Port 22 to the downstream braking equipment of Service Braking Circuit II.

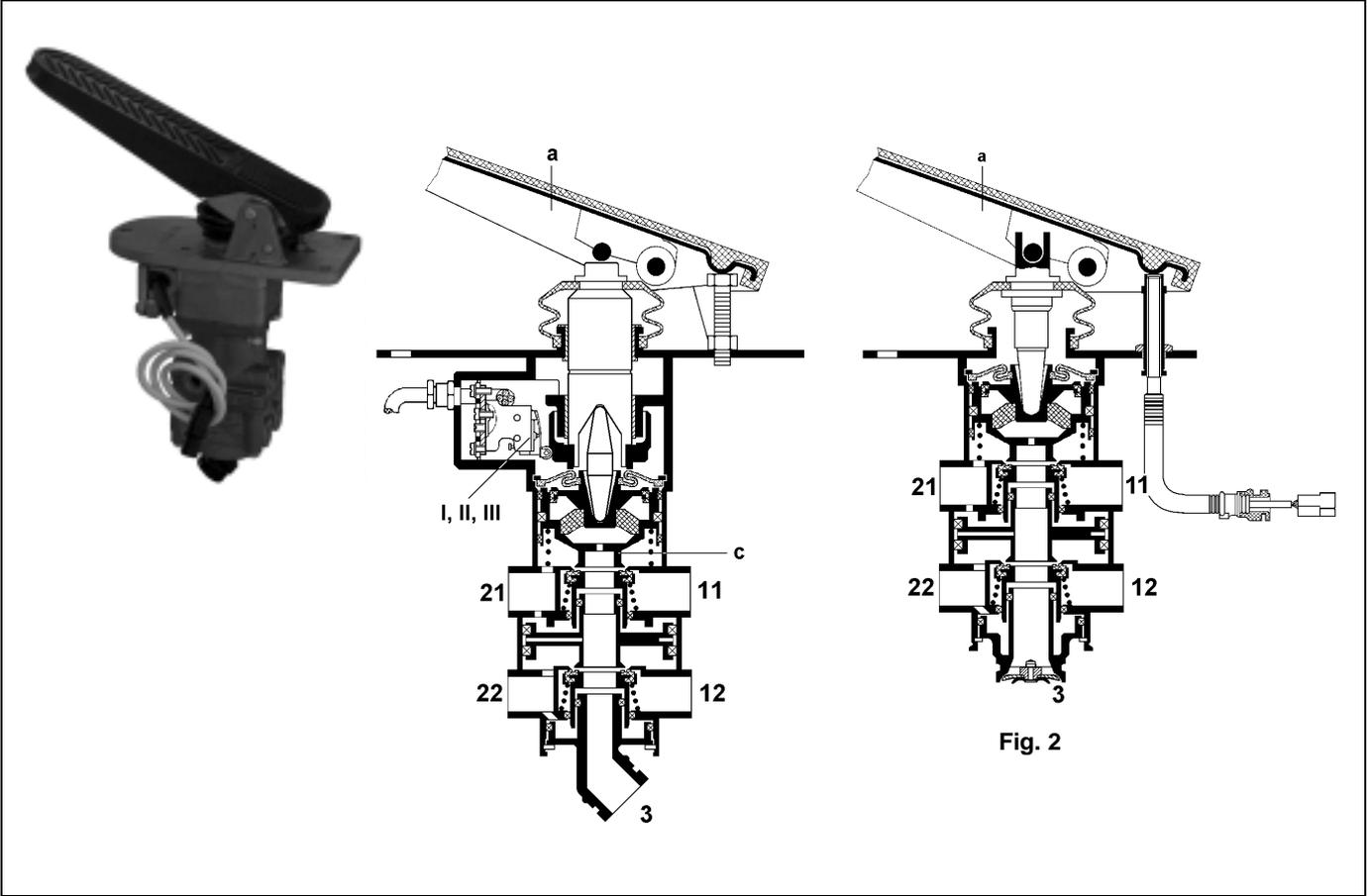
The pressure building up in Chamber A acts on the underside of piston (c). This is forced upwards against the force of the rubber spring (b) - in variants 180 against the force of the pressure springs - until the force acting on both sides of piston (c) is balanced. In this position, inlet (j) and outlet (d) are closed, and a neutral position has been reached.

Similarly, as the pressure is increased in Chamber C, acting on the underside of piston (f), forcing it upwards again until its neutral position has been reached. Inlet (g) and outlet (h) are closed.

When the brakes are fully actuated, piston (c) is moved into its lower neutral position and inlet (j) remains open. The pressure in Chamber B also forces piston (f) into its lower neutral position, keeping inlet (g) open. The full amount of air supply flows into both service braking circuits.

When the pressure in the service braking circuit is to be decreased, this process is reversed and can also be achieved gradually. The pressure in Chambers A and C forces the pistons (c and f) upwards. The pressure in both circuits of the service braking system is now reduced partially or fully, depending on the position of the plunger, through opening the outlets (d and h) and Vent 3.

In the event of one circuit failing, e. g. Circuit II, Circuit I continues to operate as described. If, however, Circuit I fails, piston (f) is moved downwards by the valve body (e) when the brakes are actuated. Outlet (h) closes and inlet (g) opens. A neutral position has been reached, as described above.



**Brake Valve With Electrical Switch Or Sensor 461 318 . . . 0**

**Purpose:**

Sensitive increase or decrease in the pressure in the dual-circuit service braking system of the motor vehicle and electrical actuation of the retarder.

**Operation:**

When the treadle (a) is pushed down, Switch I and subsequently, when the mechanical pressure point has been overcome, Switch II are actuated. This causes the first or second braking stage of the retarder to be activated without any compressed air flowing into the service braking system.

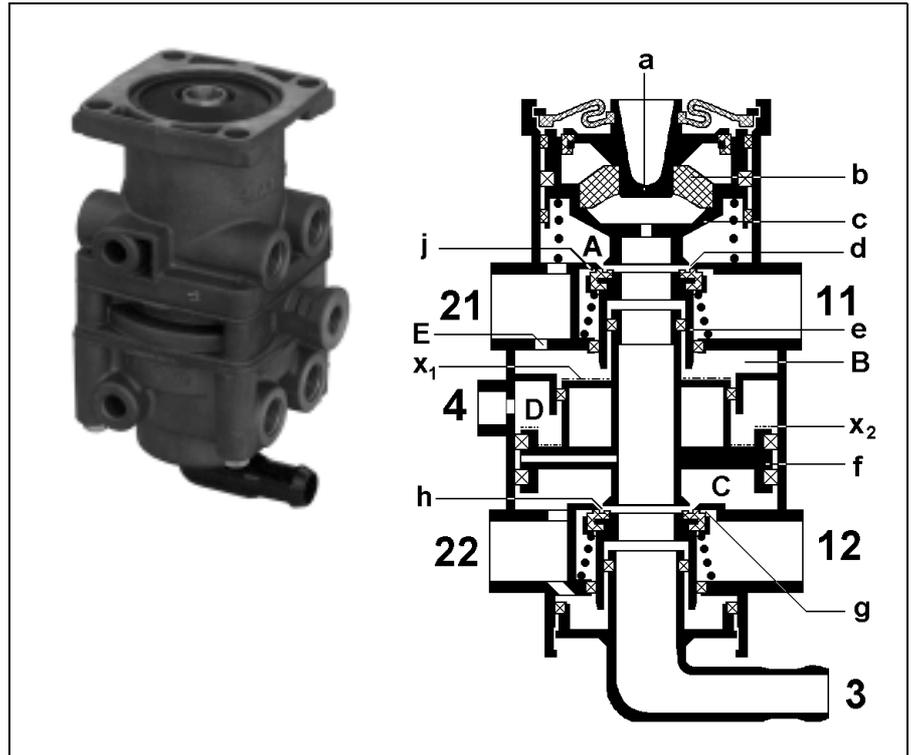
As the treadle (a) is pushed down further, Switch III is actuated, activating the third braking stage of the retarder. At the same time the piston (c) moves downward.

The operation of this brake valve is similar to that of 461 315 (description on Page 29).

When the pressure in the two circuits of the service braking system is being decreased, the switching stages of the retarder are deactivated as the treadle (a) moves upwards.

Fig. 2 shows a treadle with a built-in proximity switch which is activated when the treadle has moved through approx. 2 degrees.

## Brake Valve 461 319 . . . 0



### Purpose:

Sensitive actuation of the dual circuit truck during brake application and release service brake system. Automatic control of the front brakes through the integrated auto load proportioning valve.

### Operation:

Operation of pushrod located in spring seat (a) forces piston (c) downward, closing outlet (d) and opening inlet (j). Supply pressure at port 11 flows via chamber A and port 21 to brake boosters installed downstream as part of service brake circuit I. At the same time compressed air flows through port E into chamber B, exerting pressure against surface  $x_1$  of piston (f). This is forced downward, opening outlet (h) and closing inlet (g). Supply pressure air at port 12 flows via chamber C and port 22 to brake boosters fitted downstream as part of service brake circuit II.

Actual pressure reaching circuit II (see pressurized air circuit) is dependent on pressure modulated by the automatic load proportioning valve. This reaches chamber D via port 4, exerts pressure against surface  $x_2$  of piston (f), thus augmenting the force exerted against the top of piston (f).

The pressure built up in chamber A exerts a force against the bottom of piston (c). This is forced upward against the pressure exerted by rubber spring (b) until pressure is equalized at both ends of piston (c). Both inlet (j) and outlet (d) are closed in this position. An end position is reached.

Correspondingly, pressure built up in chamber C forces piston (f) to move upward again, until here too an end position is reached. Both inlet (g) and outlet (h) are closed.

When brake is applied fully, piston (c) is forced to its lower end position, while the outlet (j) remains open at all times. The supply pressure air acting on surface  $x_1$  via port E in chamber B, augmented by the full brake pressure of the rear axle circuit, forces piston (f) into its lower end position. Inlet (g) is opened and the supply pressure air flows unimpeded into both service brake circuits.

The two service brake circuits are exhausted in reverse sequence. This too can be carried out in steps. The brake pressure built up in chambers A and C forces the pistons (c) and (f) upwards. Both service brake circuits are fully or

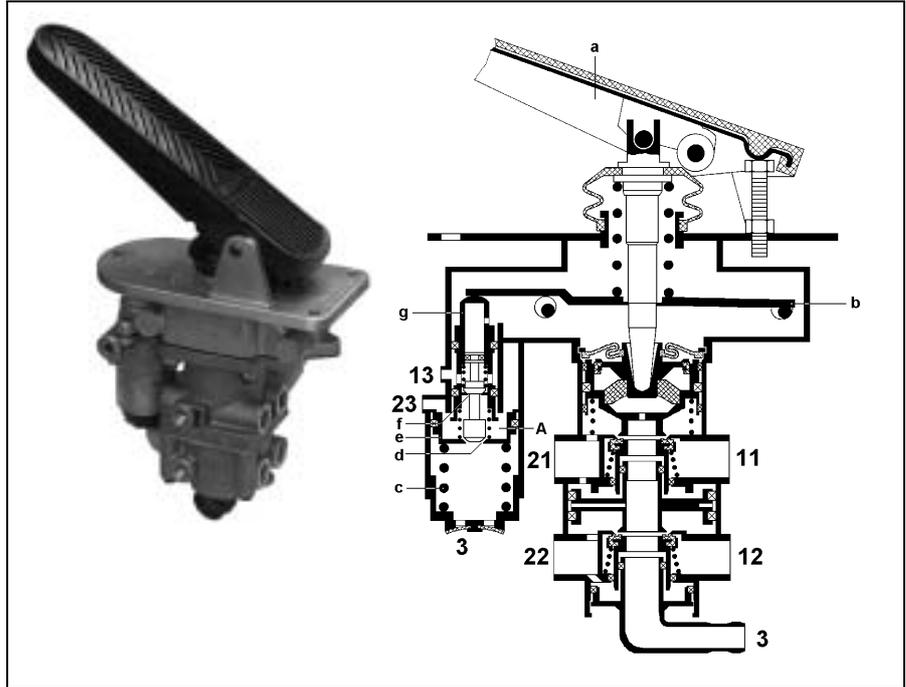
partially exhausted - depending on pushrod position - via the outlets (d) and (h) as these open, as well as through vent 3. The pressure in chamber D is reduced via the automatic load proportioning valve fitted upstream.

If pressure is lost in one circuit, e. g. circuit II, circuit I continues to function in the manner described. If, however, there is a loss of pressure in circuit I, piston (f) is forced downward by valve body (e) when brakes are applied. Outlet (h) closes and inlet (g) opens. An end position is reached as described above.

# 1.

## Brake Valves

### Brake Valve 461 324 . . . 0



#### Purpose:

Sensitive increase or decrease in the pressure in the dual-circuit service braking system of the motor vehicle and pneumatic control of the retarder via the built-in pressure control valve.

#### Operation:

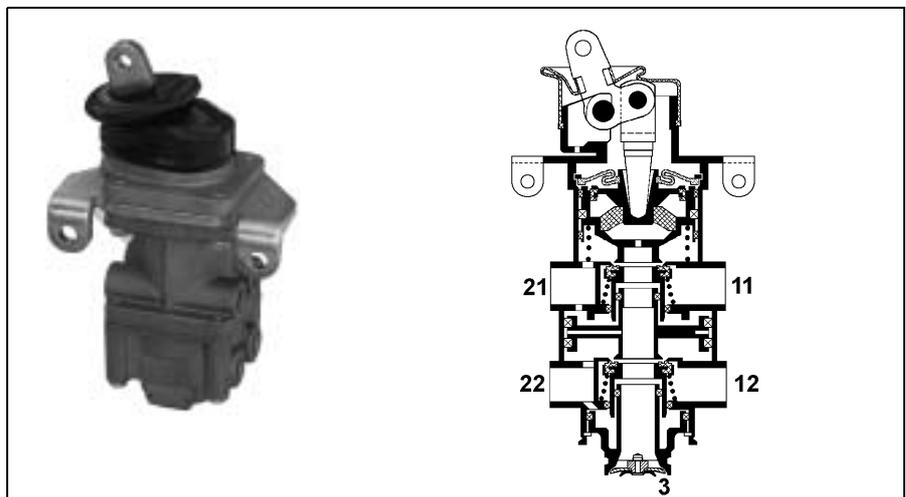
When the treadle (a) is pushed down, the lever (b) initially moves the valve (g) downwards. Outlet (d) closes and inlet (f) opens. The air supply present at Port 13 flows through Chamber A and Port 23 to the downstream retarder. The pressure building up in Chamber A acts on the piston (e). As soon as the force resulting therefrom is greater than that of the pressure spring (c), the piston (e) is forced downwards. Inlet (f) closes and a neutral position has been reached. As the treadle (a) is pushed down further, the pres-

sure at Port 12 is increased as a ratio of treadle travel. At the end of the idle travel, the pressure in Chamber A is greater and the pressure is no longer increased at Port 23 when the service braking system of the motor vehicle becomes operative.

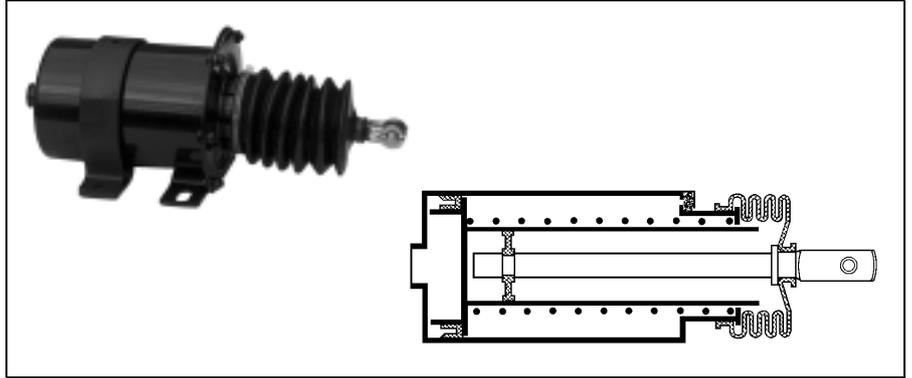
The operation of the brake valve is similar to that of 461 315 (description on Page 29).

When the pressure in the two circuits of the service braking system has been decreased, the valve (g) is again pushed upwards during the idle travel of the treadle (a). Outlet (d) opens and the compressed air from Port 23 is reduced via Vent 3 of the pressure control valve.

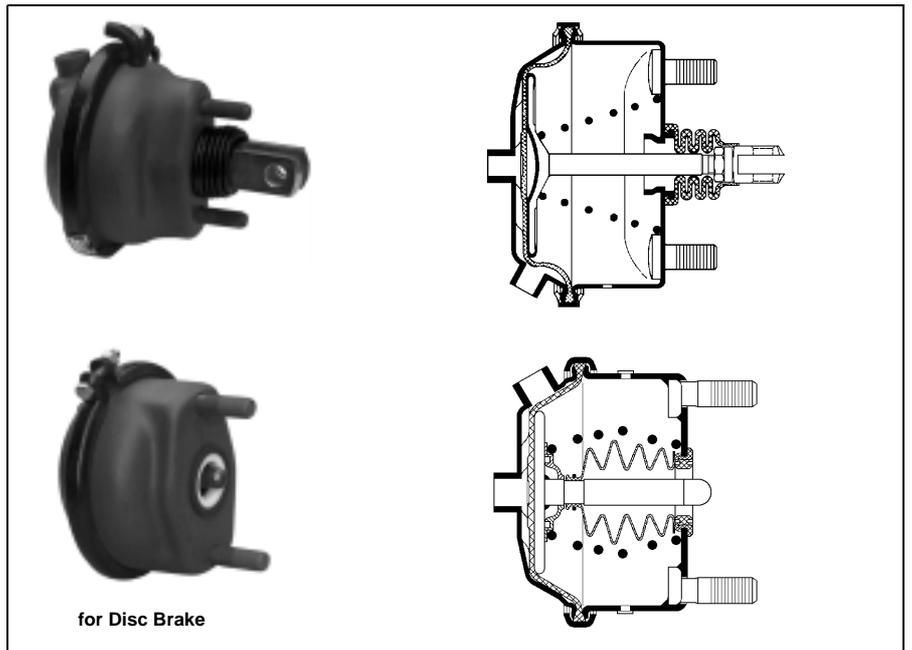
### Brake Valve With Lever 461 482 . . . 0



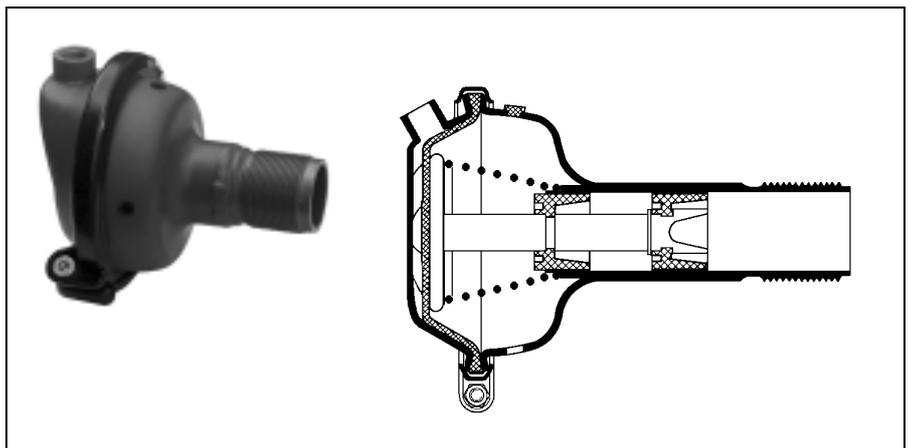
**Piston Cylinder**  
421 0 . . . . 0 and  
921 00 . . . . 0



**Brake Chamber**  
423 00 . . . . 0 and  
423 10 . . . . 0



**Brake Chamber For Expanding Wedge Brake**  
423 0 . . . . 0 and  
423 14 . . . . 0



**Purpose:**

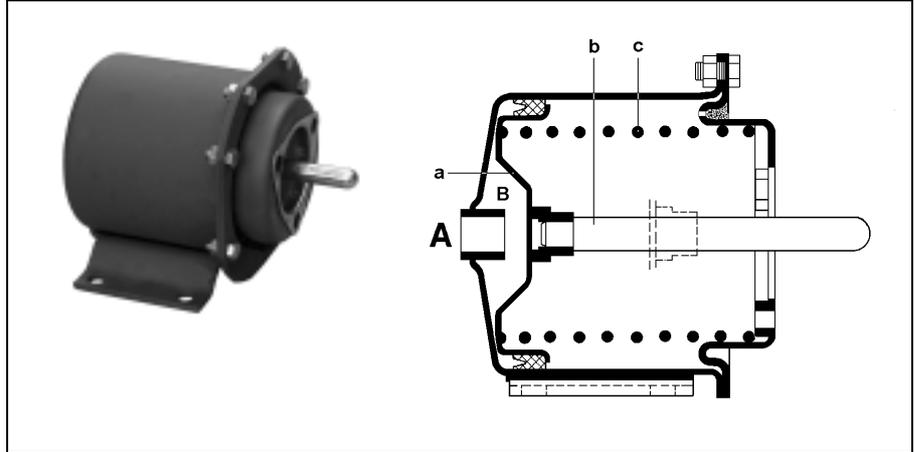
Producing the brake force at the wheel brakes using compressed air. Units are available with mechanical or hydraulic outputs.

force on the piston is transmitted through the push rod onto the brake lever (or the hydraulic master cylinder). When the pressure is released, the spring pushes the piston (or the diaphragm) back to its running condition.

**Operation:**

As soon as air enters the actuator, the

### Piston Type Air/Hydraulic Actuator 421 30 . . . . 0



#### Purpose:

Pneumatic actuation of the attached hydraulic master cylinder in air/hydraulic braking systems.

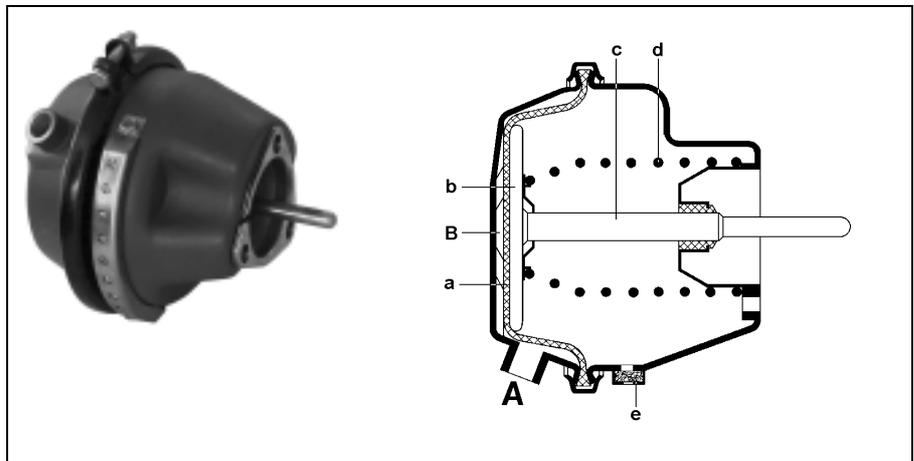
#### Operation:

When the service braking system is actuated, the compressed air from the brake

valve flows through Port A and into Chamber B. The pressure building up there forces the piston (a) to the right against the force of the pressure spring (c). Force  $F$ , this being pressure times surface, is being transferred via the pressure bar (b) onto the piston of the flanged master brake cylinder.

When the braking process is ended, the pressure in Chamber B is reduced by the upstream brake valve. At the same time, the pressure spring (c) returns the piston (a) to its original position.

### Air/Hydraulic Diaphragm Actuator 423 0 . . . . 0



#### Purpose:

Pneumatic actuation of the attached hydraulic master cylinder in air/hydraulic braking systems.

#### Operation:

When the service braking system is actuated, the compressed air from the brake valve flows through Port A and into Chamber B. The pressure building up there acts on the diaphragm (a) and pushes it, together with the piston (b), to the right against the force of the pressure spring (d). Force  $F$ , this being pressure

times surface, is being transferred via the pressure bar (c) onto the piston of the flanged master brake cylinder.

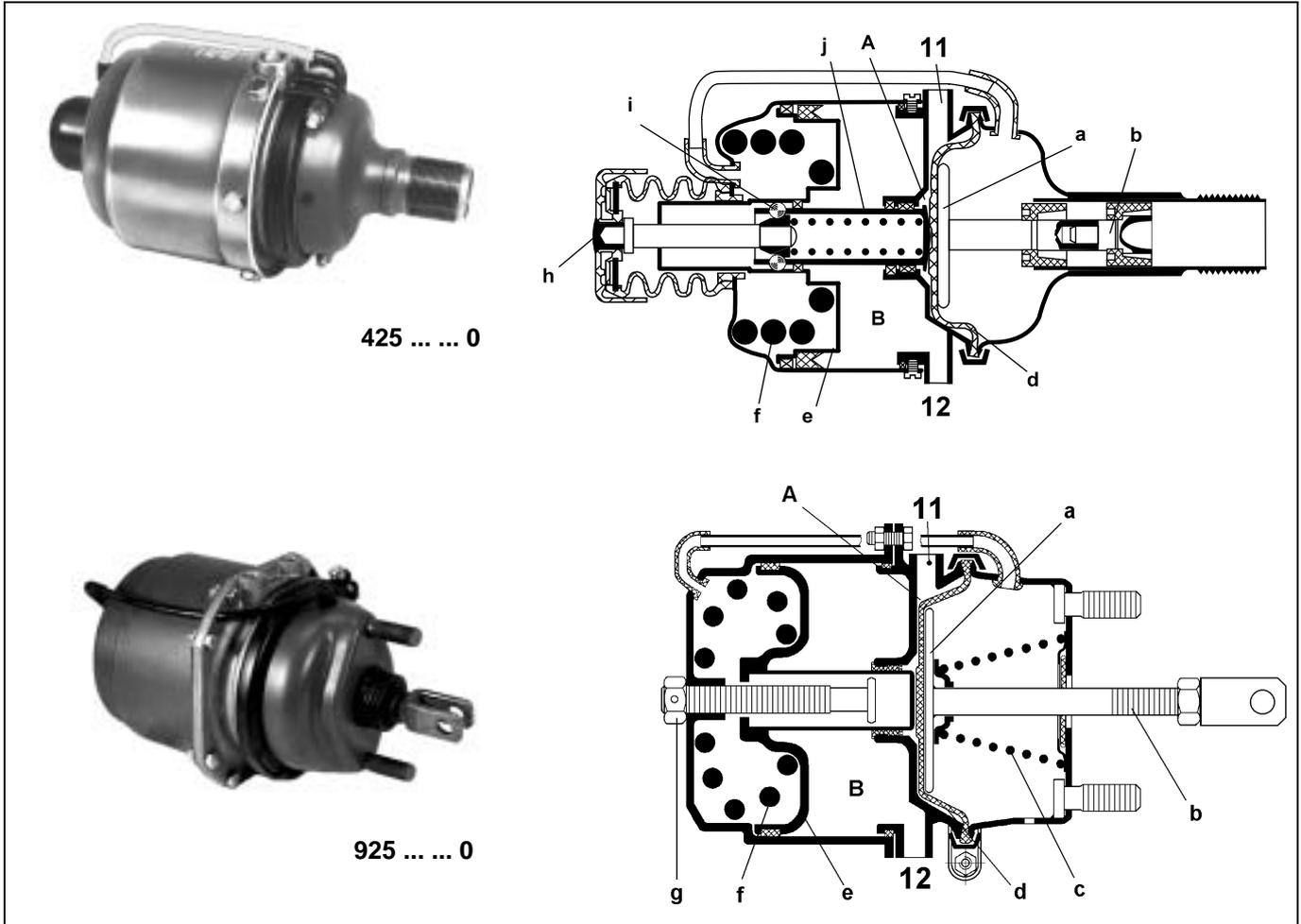
When the braking process is ended, the pressure in Chamber B is reduced by the upstream brake valve. At the same time, the pressure spring (d) returns both the piston (b) and the diaphragm (a) to their original positions.

A filter (e) fitted in front of the air outlet holes of the cylinder cover prevents dirt or dust penetrating into the inside of the

cylinder when the piston (b) returns to its original position.

These diaphragm actuators can have a wear and/or stroke indicator fitted for the driver to see which condition the wheel brakes are in.

Mechanical wear indicators are designed as drag indicators, i. e. it does not return automatically. It is actuated after 50% of the total stroke and has markings showing the driver the amount of wear on the brake linings.



## Tristop® - Spring Brake Actuator 425 3 . . . . . 0 for Expanding Wedge Brakes and 925 . . . . . 0 for Cam Brakes

### Purpose:

Combined spring brake - diaphragm brake chambers (Tristop® Spring Brake Actuators) are used to generate the brake force for the wheel brakes. They consist of the diaphragm portion for the service braking system and the spring-loaded portion for the auxiliary and parking braking systems.

### Operation:

#### a) Service Braking System:

When the service braking system is actuated, compressed air flows into Chamber A via Port 11, acting on diaphragm (d) and forcing piston (a) to the right against compression spring (c). Via piston rod (b), the force generated acts on the slack adjuster and thus on the wheel brake.

When the pressure in Chamber A is reduced, compression spring (c) moves piston (a) and diaphragm (d) back into their original positions. The brake chamber of the Tristop® Spring Brake Actuator operates independently from its spring-loaded portion.

#### b) Parking Brake:

When the parking brake is actuated, the pressure in Chamber B is fully or partially released via Port 12. In this process, the force of the relaxing compression spring (f) acts on the wheel brake via piston (e) and pressure rod (b).

The maximum braking force of the spring-loaded portion is achieved when Chamber B is pressureless. Since this braking force is achieved exclusively by mechanical means, i. e. by compression spring (f), the spring-loaded portion may be used for the parking brake. When the brake is released, the pressure is once again increased in Chamber B via Port 12.

#### c) Mechanical Release Mechanism:

For emergencies, the Tristop® Spring Brake Actuator has a mechanical release mechanism for its spring-loaded portion. Should the pressure at Port 12 fall to zero, the hexagon head screw (g) wrench size 24 can be screwed out to release the parking brake.

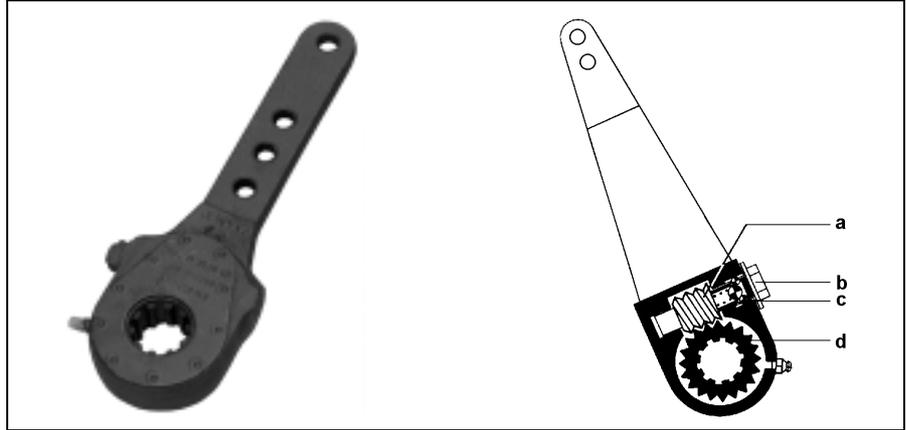
#### d) Quick-Release Facility

(only 425 ... .. 0)

To actuate the quick-release function, the bolt head (h) is hit with a hammer. This causes the balls (i) to be released from the locking mechanism and the pressure bar (f) is returned by the return forces of the wheel brake.

After remedying the loss in pressure, Port 12 is pressurized once again. The returning piston (e) again prestresses the compression spring (f). At the same time, the balls (i) lock back into place.

### Slack Adjuster 433 50 . . . . 0



**Purpose:**

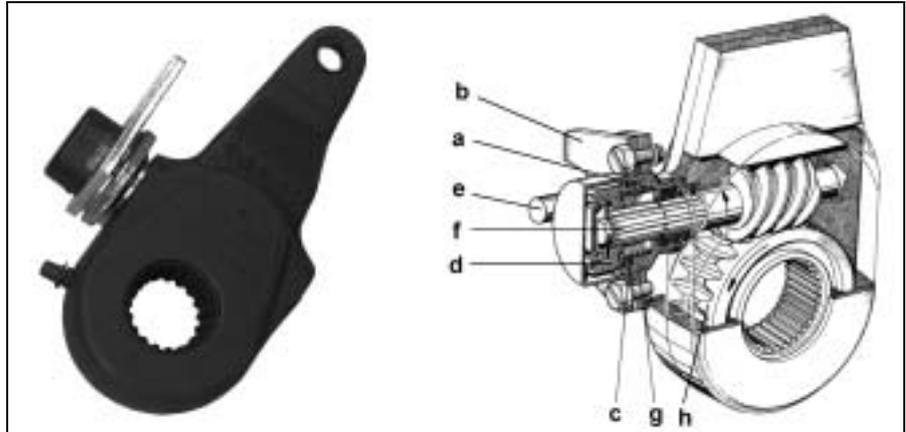
Easy, quick and continuous readjustment of the brake shaft to compensate for lining wear, making the brake cylinder operate roughly within the same stroke range.

(Particularly important for hard linings or power brakes, and if brake chambers are used, because of the shorter piston stroke.)

**Operation:**

For readjustment, a ring spanner is placed on the hexagon (b) of the Slack Adjuster's mechanism and moved by turning the worm (a). The brake shaft and thus the brake cam are readjusted via the worm wheel (d). The ball catch (c) for the hexagon (b) prevents unintentional adjustment of the Slack Adjuster.

### Automatic Slack Adjuster 433 54 . . . . 0 and 433 57 . . . . 0



**Purpose:**

Transmission of the brake forces to the wheel brake. Automatic readjustment of the brake shaft to compensate for lining wear, making the brake cylinder operate roughly within the same stroke range.

**Operation:**

When the brakes are not actuated, the lower edge of the adjuster plate's jaw is in contact with the pin (e) acting as a fixed point. When the brakes are actuated, the adjuster plate (b) covers the distance between the pin (e) and the upper edge of the jaw.

If lining wear has caused the stroke of the brake cylinder to increase, the upper

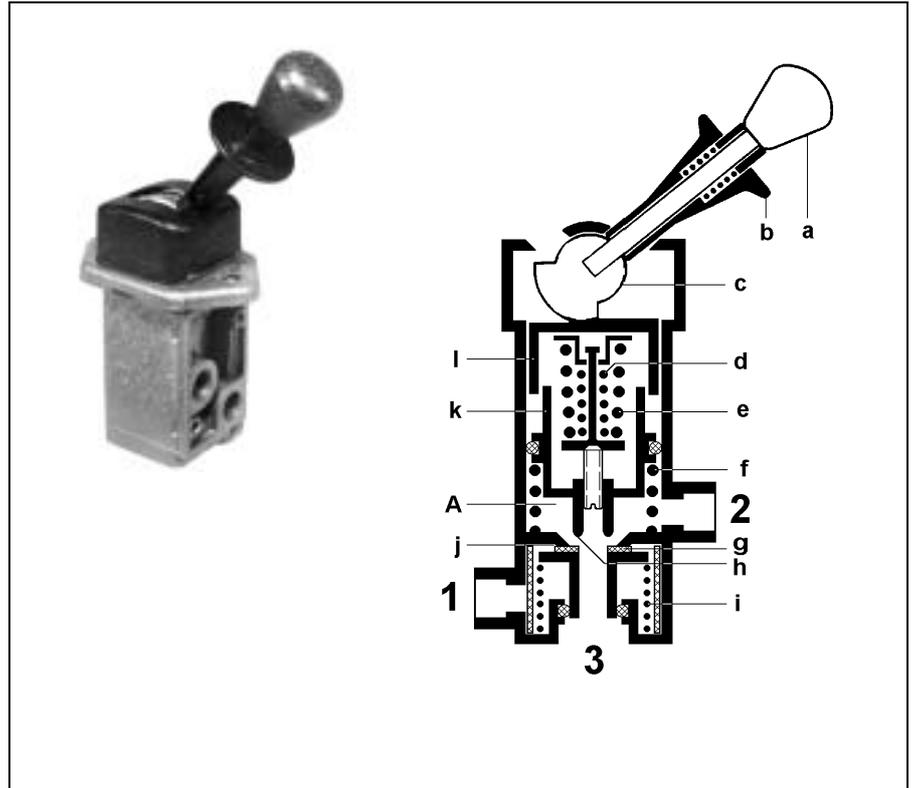
edge of the adjuster plate's jaw (b) makes contact with the pin (e) and is held there. This causes the coupling (g) connected to the adjuster plate (b) to be turned in the winding direction of the clutch spring (c) on the worm shaft (f). When the brakes are released, the Slack Adjuster returns to its original position, with the lower edge of the adjuster plate's jaw again resting against the pin (e), turning the coupling (g) on the worm shaft (f) against the winding direction of the clutch spring (c). This turning motion causes the clutch spring (c) to be unwound and to sit firmly against the hole in the coupling (g) of the adjuster ring (d). The resulting high coefficient of friction drives the adjuster ring (d) which inter-

locks with the worm shaft (f). The worm shaft (f) and the worm wheel (h) now turn the brake shaft in the operating direction, thus achieving the best possible adjustment for the wheel brake.

To prevent vibrations from turning the coupling (g) on the worm shaft (f), it is pushed against the adjuster ring (d) by the spring (a) and thus held in place.

In addition to the version described here, there is one variant which is actuated in the opposite direction. In that case, the pin (e) is in contact with the upper edge of the adjuster plate's jaw (b). Adjustment is effected in the same way.

## Hand Brake Valve 961 721 . . . 0



### Purpose:

Sensitive actuation of the trailer control valve in order to prevent jack-knifing of articulated vehicles and other tractor-trailer combinations (underrun brake).

### Operation:

In the driving position, the supply pressure at Port 1, supported by the pressure spring (i), keeps the valve (g) closed. When the hand lever (a) is in its neutral position, the cam (c) transfers no force onto piston (l). The pressure springs hold the pistons (k and l) in its upper neutral position, and Port 2 is connected with Exhaust 3.

When the hand lever (a) is actuated, the cam (c) forces piston (l) downwards. The springs (d and e) are compressed, also causing piston (k) to be displaced. The valve seat (h) closes the passage between Chamber A and Exhaust 3, and the valve (g) is raised of the valve seat (j).

The air supply flows into Chamber A and through Port 2 to the downstream trailer control valve until a pressure level is reached which is similar to the pretension of the springs (d and e). The valve (g) closes the inlet valve seat (j) without opening the outlet valve seat (h). A final position has been reached.

Any additional change in the position of the lever also causes the tension of the springs to alter and output of a corresponding control pressure as a ratio of the force applied by the cam (c). Similarly it is possible to grade evacuation, either within the partial braking range or for complete evacuation of the pilot line leading to the trailer control valve.

The Hand Brake Valve can be supplied with a feature permitting the hand lever to be locked into various positions. Locking or unlocking of this feature is achieved by pushing a button (b).

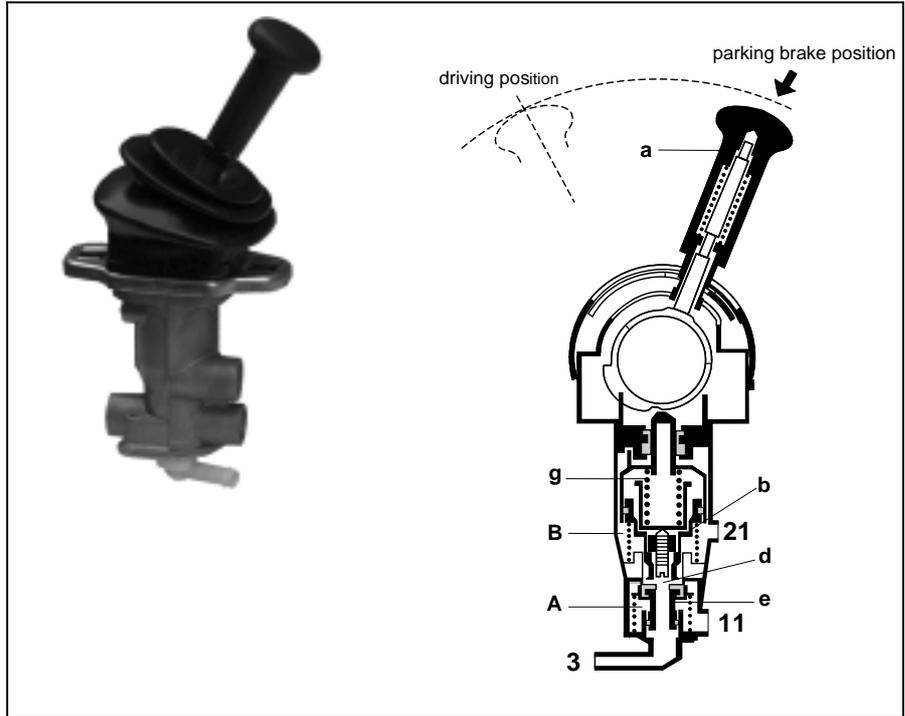
# 1.

## Hand Brake Valves

### Hand Brake Valve 961 722 1. . 0

**Purpose:**

Sensitive actuation of the auxiliary braking system and the parking brake in combination with the spring brake actuator.



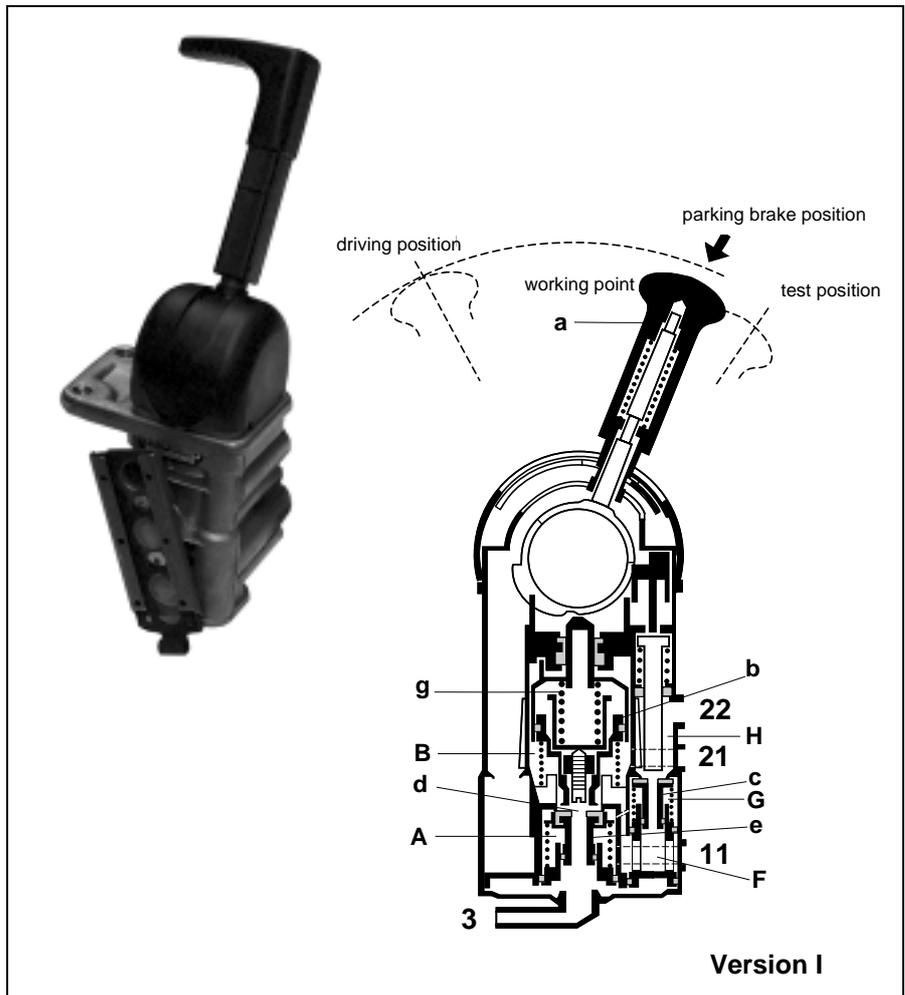
### Hand Brake Valve 961 722 2. . 0

**Purpose:**

Sensitive actuation of the auxiliary braking system and the parking brake in combination with the spring brake actuator. Control position to check the motor vehicle's parking brake.

**Design:**

The Hand Brake Valve consists of a basic valve for the auxiliary and parking braking systems which may, depending on the variant used, also have a safety circuit valve (emergency release valve) and/or a test valve.



## Operation:

In the driving position, the passage leading from Chamber A to Chamber B is open and the air at Port 11 flows through Port 21 into the spring compression chambers of the Tristop® Spring Brake Actuators. When the auxiliary braking system is actuated via the hand lever (a), valve (e) closes the passage between Chambers A and B. The compressed air from the spring compression chambers escapes to atmosphere through the open outlet (d) at Port 3. This causes the pressure in Chamber B to fall and the piston (b) is forced downwards by the pressure spring (g). As the outlet closes, a final position is reached in all partial braking positions so that there is always the right amount of pressure depending on the desired retardation.

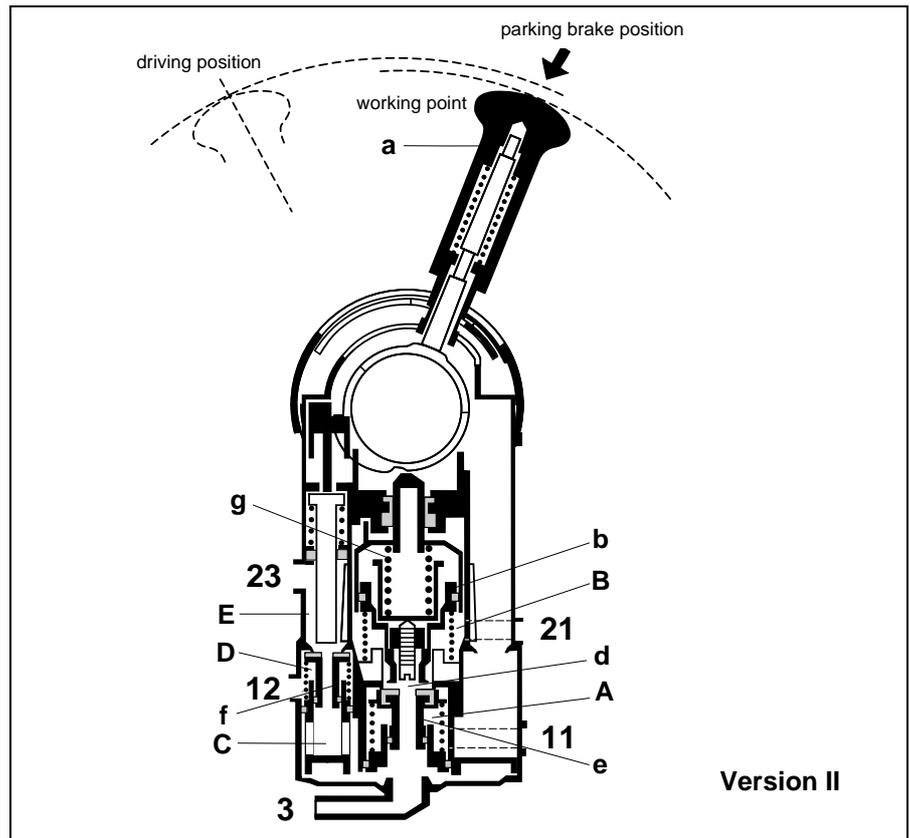
When the hand lever (a) is moved further beyond the working point, a parking brake position is reached. Outlet (d) remains open and the compressed air is evacuated from the spring compression chambers.

Within the auxiliary braking range between the driving position to the working point, the hand lever (a) will automatically return to the driving position when released.

## Version I (Variant 252)

The test valve combined with the basic valve can be used to determine whether the mechanical forces of the towing vehicle's parking brake are great enough to hold the tractor-trailer combination on a certain uphill or downhill gradient when the trailer's braking system is released.

In the driving position, Chambers A, B, F, G and H are connected and the supply pressure flows to the spring compression chambers through Port 21 and to the trailer control valve through Port 22. When the hand lever (a) is actuated, the pressure in Chambers B, F and H is reduced until it is fully evacuated when the working point has been reached. When the working point is exceeded, the actuating lever reaches an intermediate position: that of the locked parking brake. By moving the lever further to its test position, the compressed air in Chamber A flows through Chamber G and opened valve (c) into Chamber H. By pressurizing Port 22, the relay-emergency valve is actuated which in turn neutralizes the



pneumatic actuation of the brakes in the trailer which occurred when the auxiliary or parking brake was actuated. The tractor-trailer combination is now held by the mechanical forces of the towing vehicle's spring brake actuators alone. As soon as the actuating lever (a) is released, it returns to its parking brake position in which the trailer's braking system supports the parking brake.

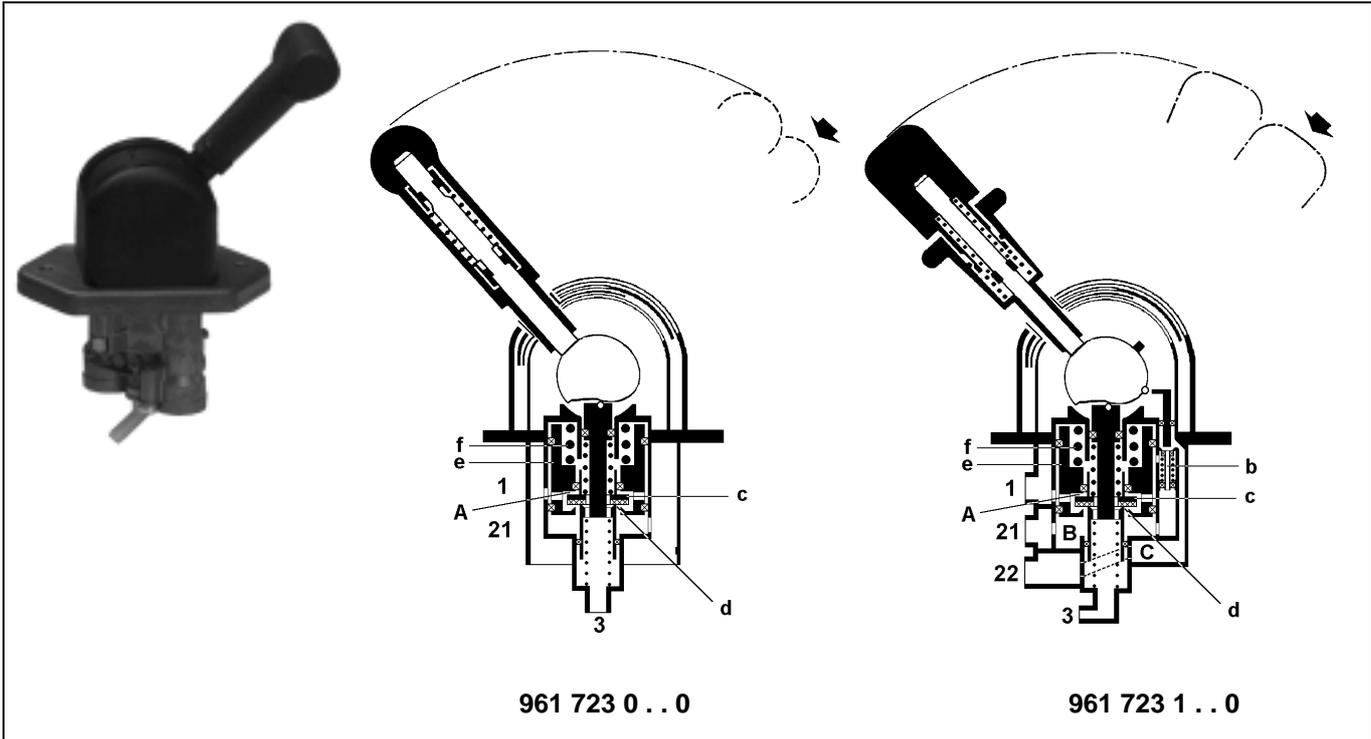
## Version II (Variant 262) for power-driven vehicles with pneumatic release device

Annex V of the Guideline of the Council of the European Community defines that spring braking systems have to have either a mechanical or a pneumatic auxiliary release device. In Version II, the basic valve has been combined with a safety circuit valve (emergency release valve) which is intended as a pneumatic auxiliary release device.

From separate supply circuits, both Ports 11 and 12 are pressurized with compressed air. The output pressures 21 and 23 reach the spring brake actuator through a 2-way valve. In the event of a

burst pipe causing the pressure to fail anywhere in the spring compression circuit, this does not cause uncontrolled emergency braking. The emergency release valve acts as a pipe rupture safeguard and protects the pressure in the spring brake actuator through the intact 2nd circuit. The driver is alerted to the defect by the release control lamp but the spring brake actuator remains in its released position.

When the hand lever (a) is turned through approx. 10°, the valve (f) will close the passage between Chambers E and D. The compressed air at Port 23 is evacuated to atmosphere through Chamber C and Port 1. Subsequently the normal, graduated function of the basic valve begins for braking or parking the vehicle.



## Hand Brake Valve

961 723 ... 0

### Purpose:

Actuation of the linkage-free auxiliary braking system and the parking brake in combination with spring brake actuators for power-driven vehicles which have no trailer attached.

Hand Brake Valve 961 723 1.. 0 is used together with spring brake actuators for linkage-free auxiliary and parking braking systems. The additional port for actuation of the trailer control valve permits the transmission of the brake forces to the trailer. A control position to check the motor vehicle's parking brake has been integrated.

### Operation:

#### 1. Auxiliary Brake

In the driving position, valve (c) keeps the passage between Chambers A and B open and the air supply at Port 1 flows through Port 21 and on into the spring compression chambers of the Tristop® Spring Brake Actuators. At the same time, compressed air flows through the test valve (b) into Chamber C and on to Port 22, acting on Port 43 of the trailer control valve.

When the auxiliary braking system is actuated by means of the hand lever (a), valve (c) closes the passage between Chambers A and B. The compressed air from the spring compression chambers escapes to atmosphere through the opened outlet (d) at Port 3. This also causes the pressure in Chamber B to drop, and the piston (e) is forced downward by the force of the pressure spring (f). As the outlet closes, a neutral position is reached in all partial braking positions, thereby ensuring that the spring compression chambers always contain the appropriate pressure for the desired retardation.

#### 2. Parking Position

When the hand lever (a) is moved further beyond the working point, the parking position is reached. The outlet (d) remains open and the compressed air from the spring compression chambers is evacuated completely.

Within the auxiliary braking range, from the driving position to the working point, the hand lever (a) will automatically return to its driving position when released.

The test valve combined with the basic valve can be used to ascertain whether the mechanical forces of the towing vehicle's parking braking system are capable

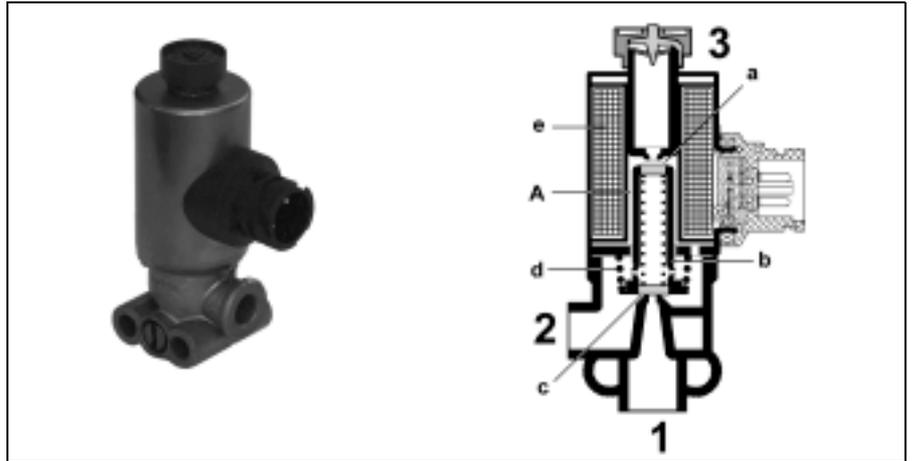
of holding the tractor-trailer combination on a certain uphill or downhill gradient when the trailer's braking system is not actuated.

#### 3. Test Position

In the driving position, Chambers A, B and C are connected and the supply pressure flows through Port 21 to the spring compression chambers and through Port 22 to the trailer control valve. When the hand lever (a) is actuated, the pressure in Chambers B and C is reduced until it is fully evacuated when the working point is reached. When moved beyond the working point, the hand lever (a) reaches an intermediate position: the locked parking position.

When the hand lever (a) is then moved further into the test position, the compressed air from Chamber A flows through the open valve (b) into Chamber C. By acting on Port 22, the relay-emergency valve is actuated which in turn neutralizes the pneumatic actuation of the brakes on the trailer caused by the use of the auxiliary or parking brake. The tractor-trailer combination is now being held by the mechanical forces of the towing vehicle's spring-brake actuators. As soon as the hand lever (a) is released, it will return to its parking brake position which assists the trailer's parking brake.

**3/2-Way Solenoid Valve normally closed**  
 472 07. . . . 0 and  
 472 17. . . . 0



**Purpose:**

To pressurize an air line when current is supplied to the solenoid.

**Operation:**

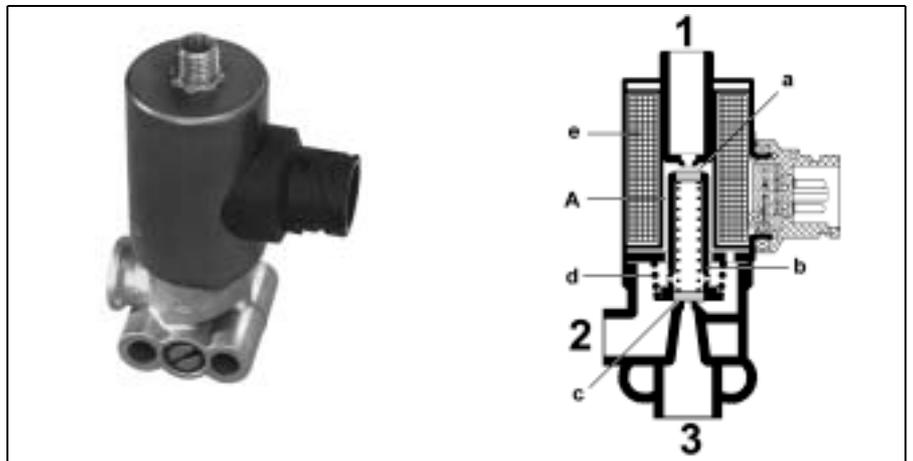
The supply line from the air reservoir is connected to port 1. The armature (b) which forms the valve core keeps inlet (c) closed by the load in pressure spring (d).

When a current reaches solenoid coil (e), armature (b) is lifted, outlet (a) is closed

and inlet (c) is opened. The compressed air from the supply line will now flow from port 1 to port 2, pressurizing the working line.

When the current to solenoid coil (e) is interrupted, pressure spring (d) will return armature (b) to its original position. Inlet (c) is closed, outlet (a) is opened and the working line is exhausted via chamber (A) and exhaust 3.

**3/2-Way Solenoid Valve normally open**  
 472 17. . . . 0



**Purpose:**

To vent an air line when current is supplied to the solenoid.

**Operation:**

The supply line from the air reservoir is connected to port 1 and thus air is allowed to flow through chamber (A) and port 2 into the working line connected to port 2. The armature (b) which forms the core of the valve is forced down by spring (d), closing outlet (c).

When a current reaches solenoid coil (e), the armature (b) is lifted, inlet (a) is clo-

sed and outlet (c) is opened. The compressed air from the working line will now escape to atmosphere via port 3 and the downstream operating cylinder is exhausted.

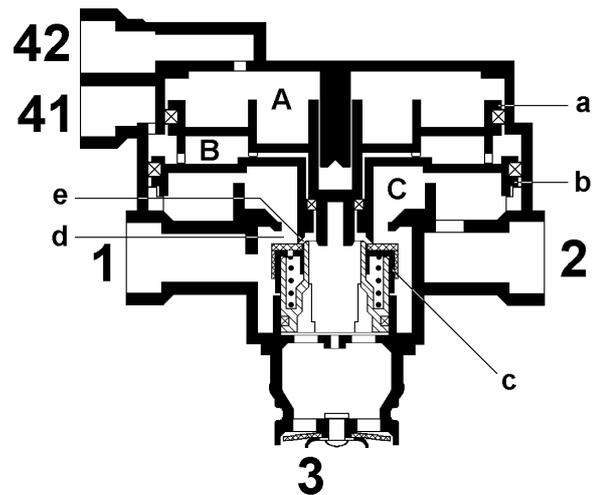
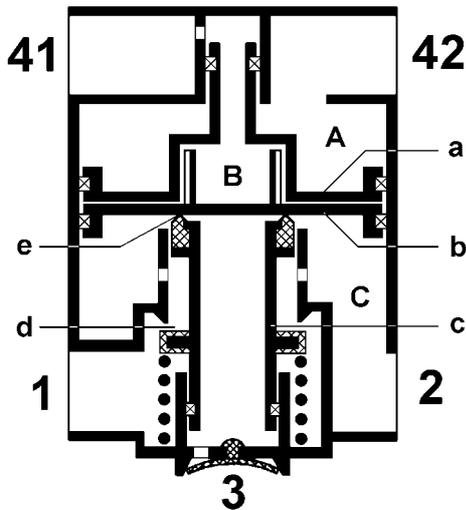
When the current to solenoid coil (e) is interrupted, pressure spring (d) will return armature (b) to its original position. Outlet (c) is closed and inlet (a) is opened, again allowing air to pass to the working line via chamber (A) and port 2.



473 017 ... 0



973 011 20. 0



### Overload Protection Valve 473 017 . . . 0 and 973 011 20 . 0

#### Purpose:

Prevention of compounding of forces in combined spring brake cylinders and brake chambers (Tristop brake actuators) during simultaneous operation of the service and spring brake systems, and thereby protection of the mechanical actuation equipment against overload. Also rapid supply and evacuation of compressed air from spring brake cylinders.

In the 973 011 20. 0 series, the usual connection (brake valve connected to Port 41 and hand brake valve connected to Port 42) will cause a reduced pressure ( $p_{42} = 8 \text{ bar}$ ,  $p_2 = 6.5 \text{ bar}$ ) to reach the spring-loaded portions of the Tristop® Spring Brake Actuators while the hand brake valve is in the driving position (saving energy in normal driving operation).

#### Operation:

##### a) Driving position.

In the driving position, chamber (A) is continuously supplied with compressed air through port 42 from the handbrake valve. The pressurized piston (a), together with piston (b), keeps outlet (e) closed and through the depressed valve stem (c) keeps inlet (d) open. Port 2 receives the full pressure from the reservoir through port 1. The spring brake cylinders connected to port 2 are supplied with compressed air (reduced if variant 973 011 20. 0 is used), and the spring brakes are released.

##### b) Actuation of the service brake system alone.

On actuation of the vehicle brake valve, compressed air flows through port 41 into chamber (B) above piston (b). Because of the counter-forces in chambers (A) and (C), the pressure reaching chamber (B) has no effect on the operation of the relay valve. The spring brake section of the Tristop actuators continues to be

supplied with compressed air and they are thus released, while the diaphragm section supplied with compressed air directly from the tractor brake valve reacts.

##### c) Actuation of the spring brake system alone.

Actuation of the handbrake valve effects partial or complete evacuation of chamber (A). Piston (a), relieved of pressure, is pushed upwards by piston (b), which is exposed to the reservoir pressure in chamber (C). Outlet (e) thereby opens, while inlet (d) is closed by the rising valve (c). This results in evacuation, according to the position of the handbrake lever, of the spring brake cylinders through port 2, valve stem (c) and exhaust port 3, so that the spring brakes are actuated. With partial brake application, outlet (e) closes after the process of evacuation and the pressure equilibrium which thereby arises in chambers (A) and (C). The relay valve is thus in the neutral position. However, with full brake application inlet (e) remains open.

**d) Simultaneous actuation of the service and spring brake systems.**

1. Service braking with evacuated, i. e., actuated spring brake cylinders. The spring brake reservoirs are evacuated. If the service brake is also actuated, compressed air flows through port 41 into chamber (B) and acts on piston (b), which since chamber (C) is evacuated, moves downwards to close outlet (e) and opens inlet (d) through valve (c). Compressed air now flows from 1 through chamber (C) to 2 and into the spring brake reservoirs. The spring brake is thereby released but only to the extent that the service brake pressure rises. There is therefore no compounding of the two braking forces.

The pressure building up in chamber (C) raises piston (b) as soon as the pressure delivered at 2 has become greater than the pressure present in chamber (B). Inlet (d) closes and the relay valve is in the neutral position.

**Relay Valve  
(Plastic Type)  
973 006 . . . 0**

2. Spring braking while service brake is being actuated.

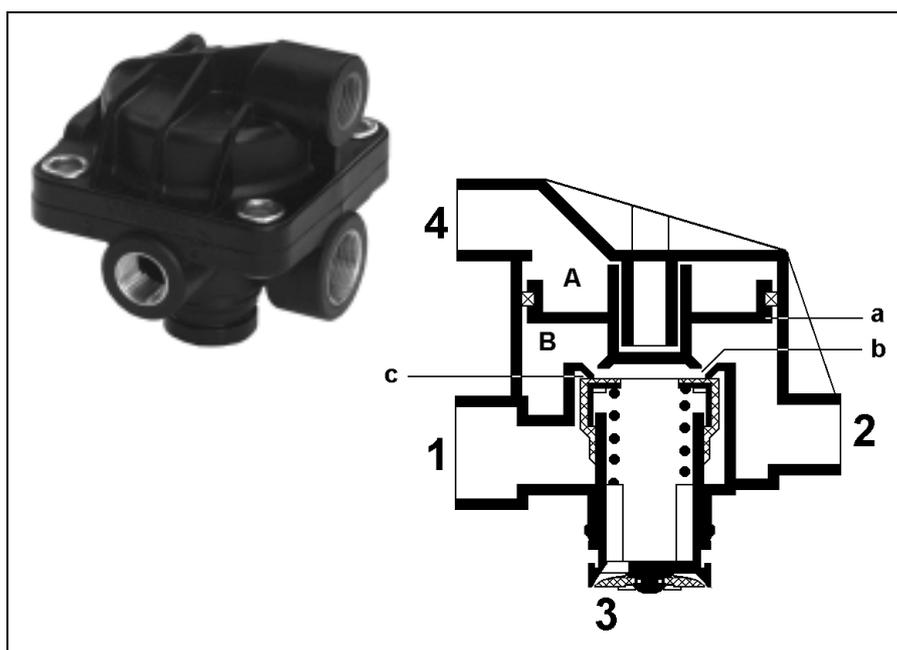
The service braking system is being actuated within the partial braking range, i. e. Chamber B is pressurized. If now the parking brake is actuated in addition, causing the pressure in Chamber A to be reduced, the supply pressure in Chamber C forces the pistons (a and b) upwards. The valve body following them closes the inlet (d) and opens the outlet (e). Depending on the level of the service braking pressure, compressed air from the spring compression chambers will be evacuated to atmosphere through the outlet (e) and Vent 3 until the pressure in Chamber B is greater once again and the piston (b) closes the outlet (e). A neutral position has been reached.

When the hand brake valve is actuated fully, Port 42 is evacuated completely. Since it is impossible for the pressure in Chamber C to be lower than that in Chamber B, the spring brake is only op-

erated to the extent permitted by the respective braking pressure. Compounding of the brake forces does not take place when the brakes are actuated fully.

On vehicles with an emergency release facility, this type of connection may not be used for Variant 973 011 2.. 0 (different diameters of pistons a and b). To prevent a difference in pressures at the downstream two-way valve, actuation of the hand brake valve must be through Port 41, and that of the brake valve at Port 42.

When the service brake is released (with parking brake still being actuated), Chamber B is evacuated once again. The pressure in Chamber C is greater, forcing piston (b) upwards. Outlet (e) opens and the spring compression chambers are connected with Vent 3.



**Purpose:**

Control of the spring-loaded portion only in the Tristop® Spring Brake Actuator and more rapid increase or decrease in pressure when the hand brake valve is actuated.

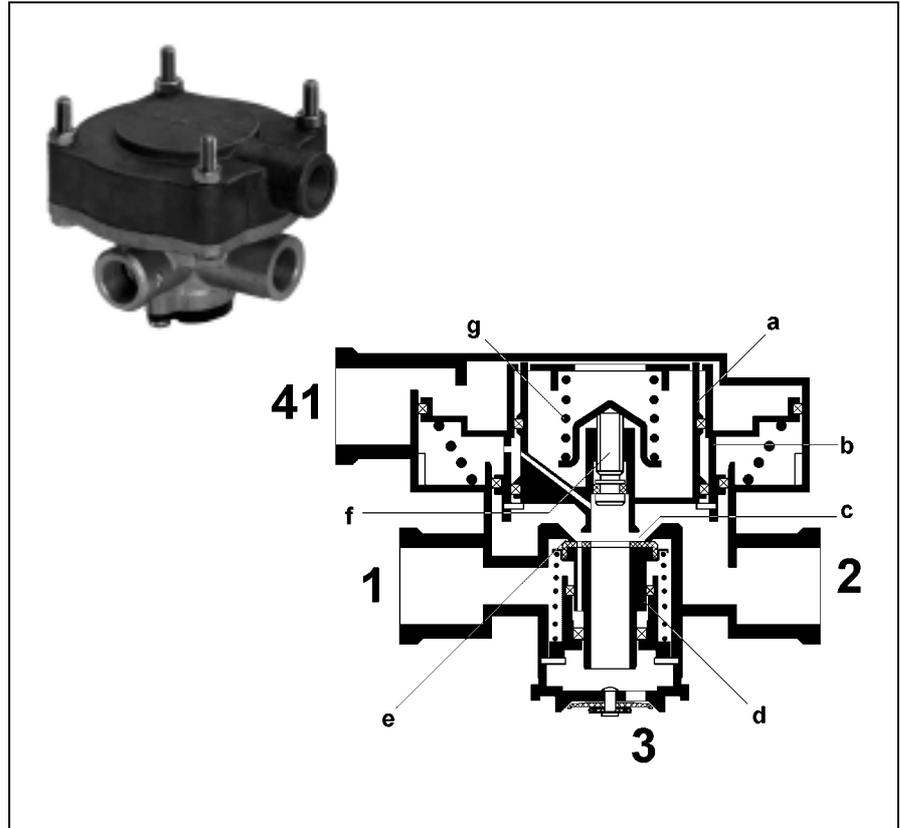
**Operation:**

The output pressure from the hand brake valve flows into Chamber A through Port 4, forcing piston (a) into its lower end position, closing the outlet (b) and opening the inlet (c). The air supply at Port 1 now

flows into Chamber B and through Port 2 into the spring-loaded portion of the Tristop® Spring Brake Actuator.

When the hand brake valve is operated, the pressure in the pilot line is partly or fully evacuated at Port 4. Piston (a) is pushed upward once again by the pressure in Chamber B, and the excess pressure at Port 2 is evacuated to atmosphere through the outlet (b) and Vent 3.

**Relay Valve With Adjustable  
Predominance**  
973 003 000 0



**Purpose:**

To rapidly increase or decrease the pressure of compressed air equipment and to shorten the response and pressure build-up times in air braking systems.

**Operation:**

When the braking system is actuated, compressed air flows through Port 41 into Chamber A, forcing the pistons (a and b) downwards. This causes the outlet (c) to be closed and the inlet (e) to be opened. The air supply preset at Port 1 flows through Chamber B and on to Port 2 to, providing pressure for the downstream brake cylinders, according to the actuating pressure, with a predominance depending on the preset initial tension of the pressure spring (g).

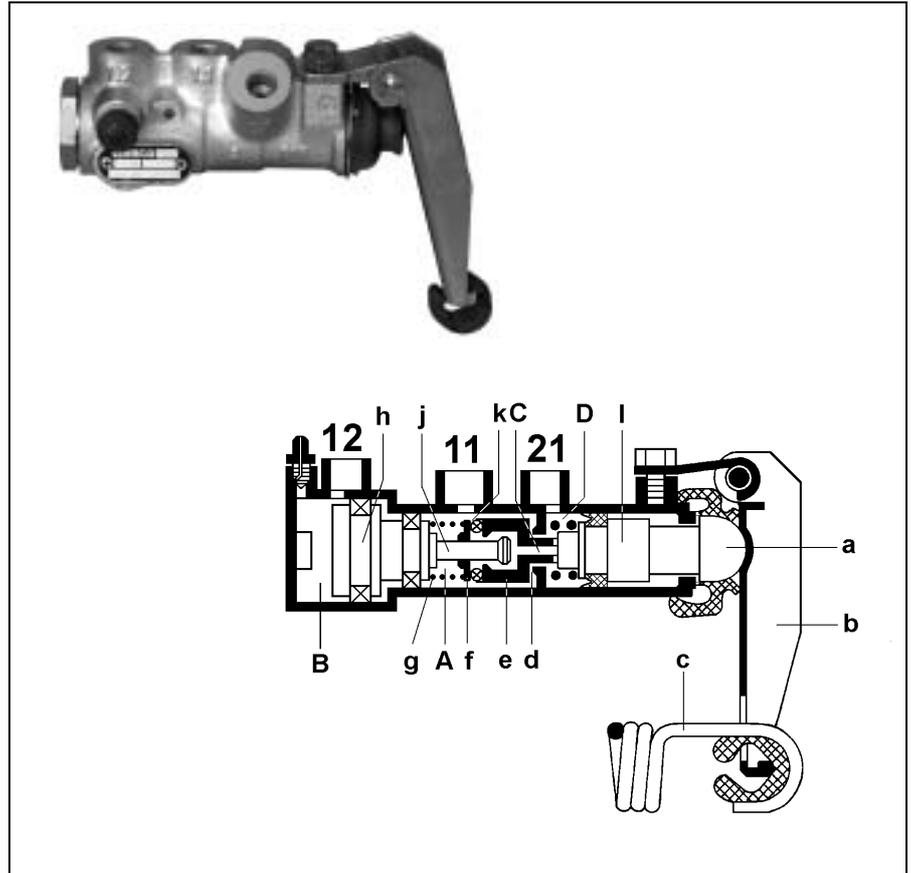
The pressure building up in Chamber B acts on the undersides of the pistons (a and b). Because of the difference in the effective areas of piston (a), only piston

(b) is forced upwards against the actuating pressure in Chamber A and the force of the pressure spring (g). The valve (d) following piston (b) closes the inlet (e) and a neutral position has been reached.

By turning the adjuster screw (f), the initial tension of the pressure spring (g) can be changed to achieve a pressure predominance of Ports 2 over Port 41 of up to 1 bar.

When the pressure in the pilot line is partially reduced, piston (a) is forced upwards once again, opening outlet (c), and the excess pressure at Ports 2 is evacuated through Vent 3. If the actuating pressure at Port 41 is fully evacuated, the pressure in Chamber B pushes pistons (a and b) to their upper neutral position and the outlet (c) opens. The downstream brake cylinders are evacuated fully through Vent 3.

## Automatic Load Sensing Valve 468 402 . . . 0



### Purpose:

Automatic regulation of the braking force at the hydraulic wheel cylinders in relation to the load on the vehicle.

### Operation:

The load sensing valve is fastened to the chassis frame and controlled by a tension spring (c), which is connected to the back axle either directly or by means of a link lever and rod. With increasing loading the distance between the axle and the frame changes. As a result the tension spring (c) is more heavily loaded and the resulting force is carried through the lever (b), the bolt (a) as well as the piston (l) to the load sensing valve.

On applying the service brake system and with it the hydraulic brake master cylinder, the hydraulic brake pressure building up in the rear axle circuit passes through port 11 into space (A). The pressure travels further through the opened

passage (d), into space (D) and port 21 to the rear axle wheel cylinders. At the same time the brake pressure in the front axle circuit passes through the port 12 into space (B) and moves the piston (h) to the right and end of its stroke against the force acting on its rear side in space (A). Should the hydraulic brake pressure inside the rear axle circuit and therefore in space (D) rise above the valve, which corresponds with the spring force applied at the lever (b), the pressure in space (D) moves the piston (l) to the right. The valve (e) closes the passage (d) and a shut-off position is reached.

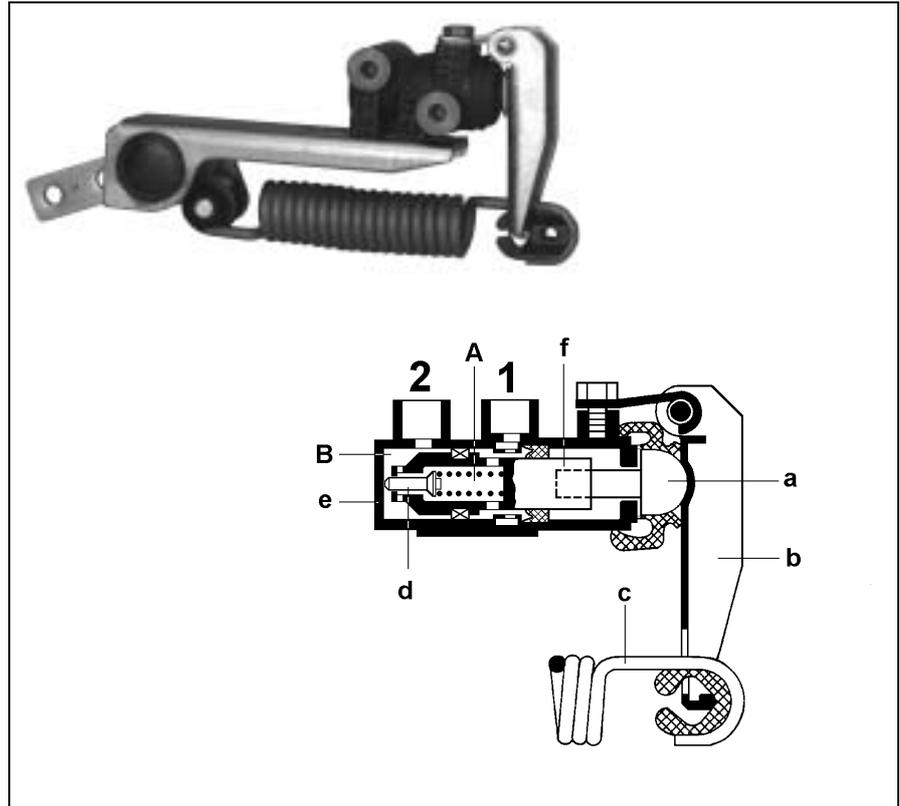
With a further increase in pressure at port 11, the valve (e) remains closed, and no increase in the output pressure takes place (cut-off characteristic).

With a reduction in the hydraulic pressure at port 11 the higher pressure in space (D), which acts through the drilling

(C) on the non-return valve (f), moves this to the left against the force of the spring (g). The brake pressure in the rear axle circuit now falls through the drilling (C), the by-pass (k) and the port 11. The force of the tension spring (c) presses the piston (l) back to the left, the valve (e) opens the passage (d) and the brake pressure now passes through the passage (d) to port 11.

Should the front brake circuit fail the hydraulic brake pressure will only build up on applying the service brake system in spaces (A and D). With it the piston (h) is pressed to the left and end of its stroke. The valve tappet (j) pulls the valve (e) up and the passage (d) remains constantly open. The hydraulic brake pressure now passes unhindered to the rear axle wheel cylinders.

### Automatic Load Sensing Valve 468 404 . . . 0



#### Purpose:

Automatic regulation of the braking force at the hydraulic wheel cylinders in relation to the load on the vehicle.

#### Operation:

The load sensing valve is fastened to the chassis frame and controlled by a tension spring (c) which is connected to the axle either directly or by means of a link lever and rod. With increasing loading the distance between the axle and the frame changes. As a result the tension spring (c) is more heavily loaded and the resulting force is transmitted through the lever (b), the bolt (a) and the piston (f) to the brake apportioning valve.

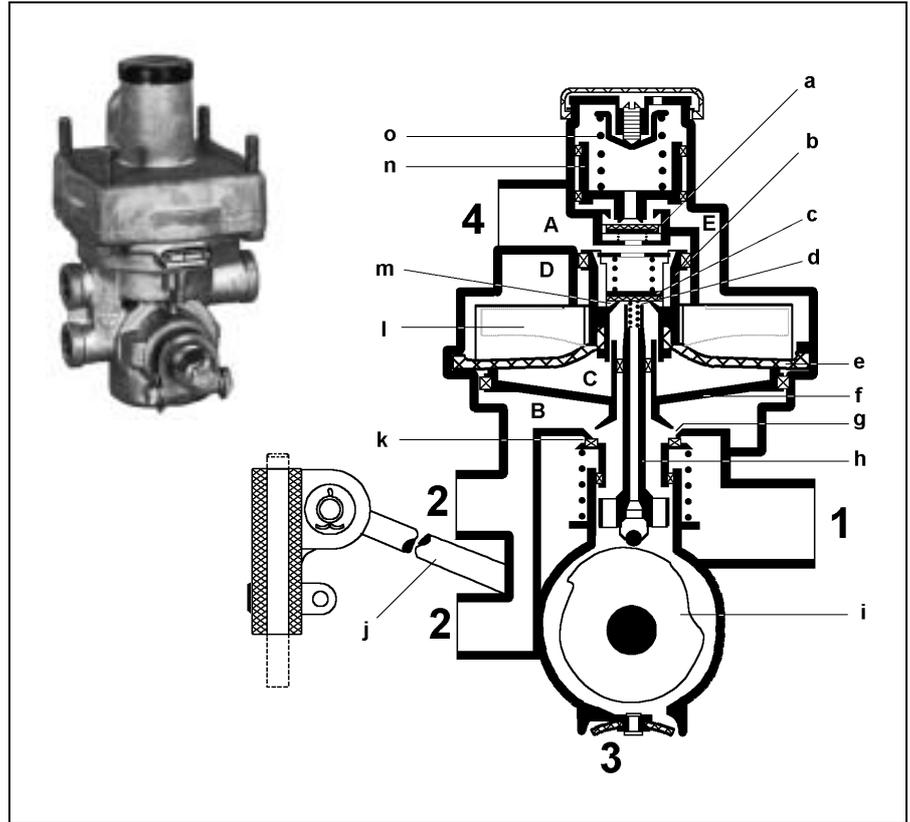
On applying the service brake system and with it the hydraulic brake master cylinder the hydraulic brake pressure building up in the rear axle circuit passes through port 1 into space (A), the pressure passes through the opened valve (d) into space (B) and further through port 2 to the rear axle wheel cylinders. Should the hydraulic brake pressure inside the rear axle circuit and therefore in space (B) rise above the valve, which corresponds with the spring force applied at the lever (b), the pressure in

space (B) moves the piston (f) to the right. The valve (d) closes and a shut-off position is reached.

With a further increase in pressure at port 1, and therefore in space (A) the piston (f) is again moved to the left. The valve (d) opens and fluid passes through port 2 to the wheel cylinders, increasing the pressure. When the force to the right on piston (f), resulting from the pressures in spaces (A and B) again reacts the valve corresponding to the spring force applied at the lever (b), the valve (d) closes again.

With a reduction in the hydraulic brake pressure at port 1 and with it also in space (A), the valve (d) is opened through the pressure present in space (B). The brake pressure in the rear axle circuit is now reduced through port 1 and the previously operated master cylinder. The force of the draw spring (c) transmitted by the bolt (a) presses the piston (f) back to the leftward end of its stroke during a pressure decrease in space (B). The valve (d) rests on the housing (e) and remains open.

### Automatic Relay Load Sensing Valve 475 710 . . . 0



#### Purpose:

To automatically control the braking force as a function of the spring deflection and thus of the vehicle load. The integral relay valve ensures rapid supply and exhaust of the brake actuators.

#### Operation:

The valve is mounted on the vehicle chassis and connected to a fixed point on the axle by a flexible arm or a linkage. When the vehicle is empty, the distance between the axle and the valve is greatest and lever (j) is in its lowest position. As the vehicle is loaded, this distance is reduced and lever (j) moves from its "empty" position towards its "fully laden" position. The movement of lever (j) causes cam (i) to rotate and to lift valve tappet (h) to a position corresponding to the vehicle load.

On application of the brakes, air from the truck foot-brake valve or relay emergency valve enters chamber (A) via port 4, forcing down piston (b). Outlet (d) is closed and inlet (m) opened. Compressed air at port 4 reaches chamber (C) below diaphragm (e), acting on the effective surface area of relay piston (f).

At the same time, air flows into chamber (D) via opened valve (a) and passage (E), acting on the upper side of diaphragm (e). This initial by-pass pressure eliminates any reduction in pilot pressure (up to 1.0 bar max.) in the "partially laden" condition. As the pilot pressure continues to rise, piston (n) is forced up against the load of spring (o), closing valve (a).

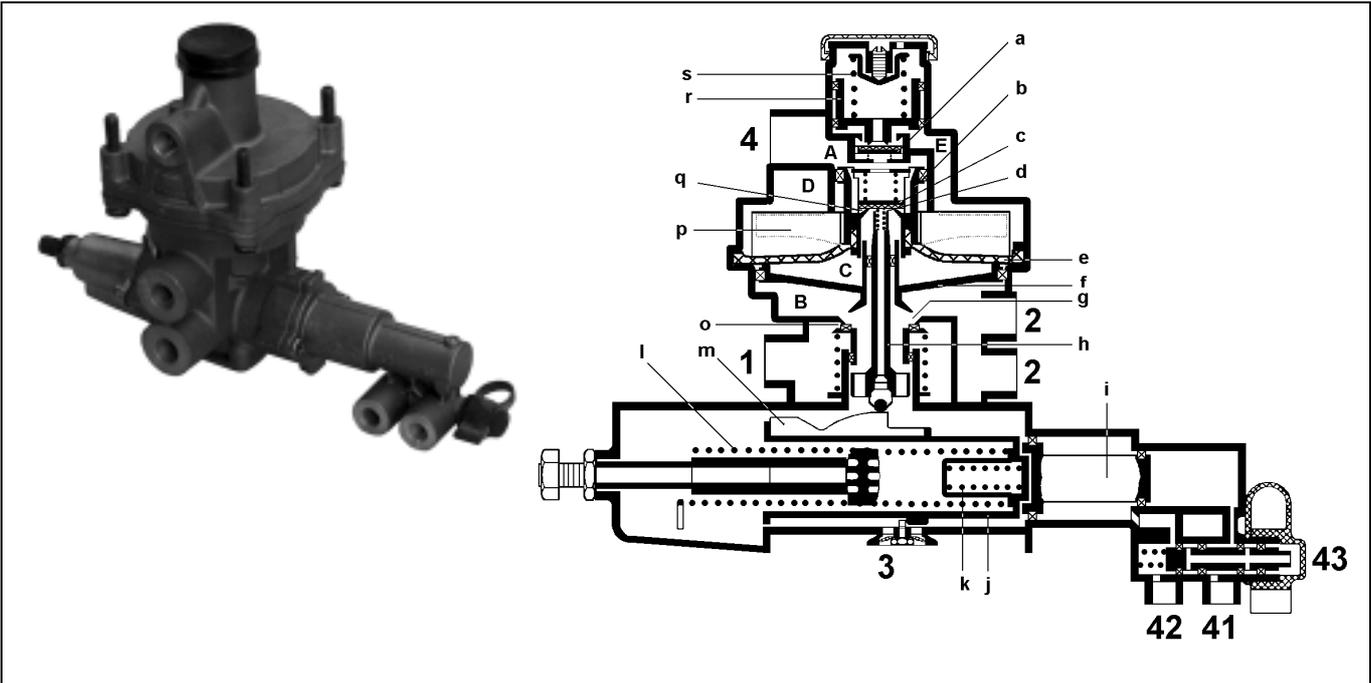
The pressure building up in chamber (C) forces down relay piston (f). Outlet (g) closes and inlet (k) opens. The supply pressure at port 1 now flows into chamber (B) via inlet (k) and to the brake actuators via ports 2. At the same time, pressure builds up in chamber (B) acting on the underside of relay piston (f). As soon as this pressure exceeds the pressure in chamber (C), relay piston (f) slides down, closing inlet (k).

As piston (b) moves down, diaphragm (e) is forced against vane (l). As soon as the force in chamber (C) acting on the underside of the diaphragm is equal to the force acting in piston (b), the piston moves upward. Inlet (m) is closed. A balanced position is reached.

The position of valve tappet (h) which is controlled by the position of lever (j) determines the output pressure. Piston (b) with vane (l) need to cover a certain stroke depending on the position of valve tappet (h) before valve (c) begins to operate. This stroke also changes the effective surface area of diaphragm (e). In the "fully laden" position, the input pressure at port 4 is the same as that reaching chamber (C). As full pressure is applied to relay piston (f), it keeps inlet valve (k) open and the brake pressure is not regulated.

When the pilot pressure at port 4 is reduced, relay piston (f) is forced up by the pressure in ports 2. Piston (b) is forced up by the pressure in chamber (C). Outlets (d and g) open and the compressed air escapes to atmosphere via exhaust 3.

In the event of the linkage breaking, the valve will automatically move to the emergency control curve of the cam (i) whose output pressure is approximately half the service braking pressure when the vehicle is fully laden.



## Automatic Load Sensing Valve 475 711 . . . 0

### Purpose:

Automatic control of the brake force depending on the bellows pressure and thus on the load of the vehicle. The integrated relay valve assures quick pressurizing and venting of the brake cylinders.

### Operation:

The load-sensing valve is actuated by the pressure of both circuits of the air bellows from Ports 41 and 42. The piston valve (i) pushes the working piston (j) with the radial cam (m) to the left against the force of the spring (l). This causes the radial cam (m) to take the valve tappet (h) to the appropriate position for the vehicle's load.

The compressed air output by the brake valve flows through Port 4 and on into Chamber A, acting on the piston (b). This is forced downward, closing the outlet (d) and opening the inlet (q). The compressed air from Port 4 flows into Chamber C beneath the diaphragm (e), acting on the effective area of the relay piston (f).

At the same time, compressed air flows through the open valve (a) and Duct E into Chamber D, acting on the upper side of the diaphragm (e). This pressure predominance causes the reduction in the partially-laden range to be neutralized at

low actuating pressures (up to 0.8 bar). As the actuating pressure continues to rise, the piston (r) is forced upwards against the force of the spring (s) and the valve (a) closes.

The pressure building up in Chamber C forces the relay piston (f) downwards. The outlet (g) closes and the inlet (o) opens. The air supply at Port 1 now flows through the inlet (o) into Chamber B and through Ports 2 to the downstream compressed-air brake cylinders. At the same time, pressure builds up in Chamber B which acts on the underside of the relay piston (f). As soon as this pressure exceeds that in Chamber C, the relay piston (f) moves upwards, closing the inlet (o).

As the piston (b) moves downwards, the diaphragm (e) makes contact with the fan-type disk (p), thereby continuously increasing the effective diaphragm area. As soon as the force in Chamber C which acts on the underside of the diaphragm (e) is equal to the force acting on the piston (b), that piston moves upwards. Inlet (q) is closed and a neutral position has been reached.

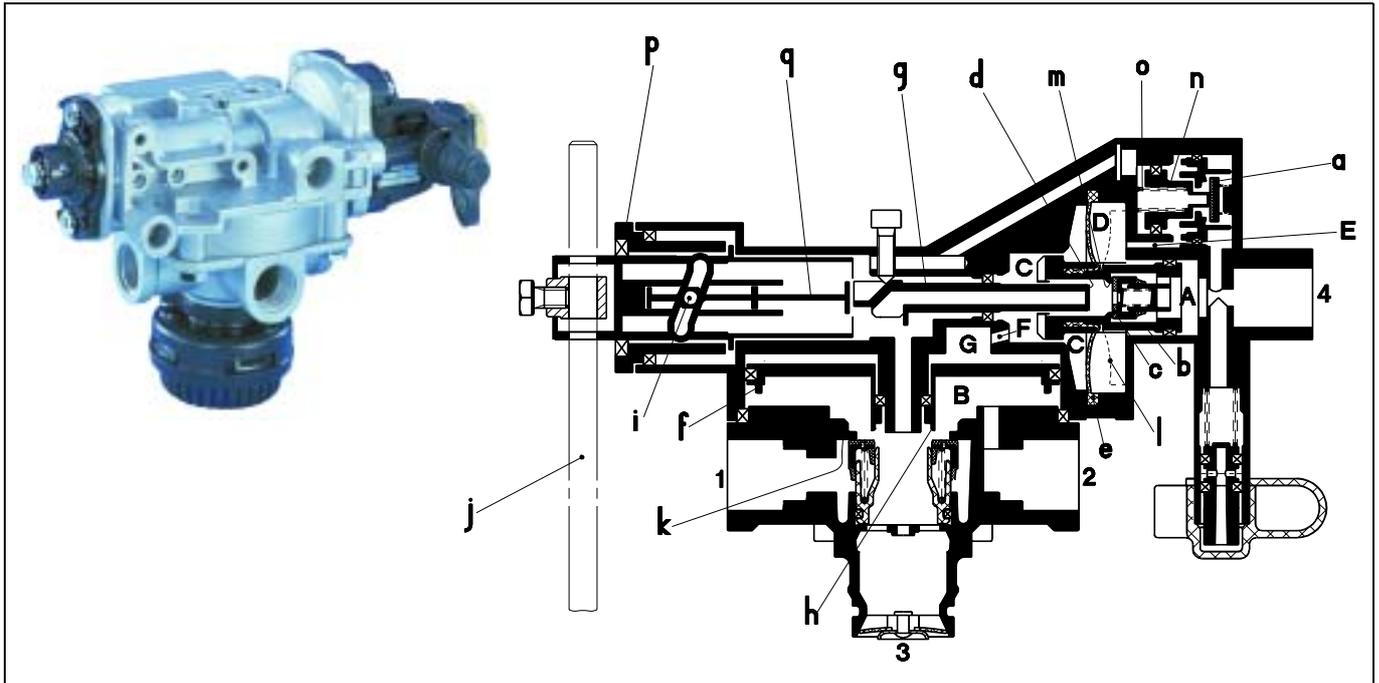
The position of the valve tappet (h) which depends on the position of the radial cam (m) determines the output control pressure. The piston (b) with the fan-type disk (p) must have covered a stroke depending on the position of the valve tappet (h) before the valve (c) begins to act. This

stroke also causes the effective area of the diaphragm (e) to be changed. In the fully-laden position, the output pressure from Port 4 is passed on into Chamber C at a ratio of 1:1. The full pressure acting on the relay piston (f) causes the inlet (o) to be kept open and the input control pressure is not adjusted.

When the actuating pressure at Port 4 is reduced, the pressure in Ports 2 forces the relay piston (f) upwards and the piston (b) is forced upwards by the pressure in Chamber C. The outlets (d and g) open and the compressed air is evacuated to atmosphere through Vent 3.

If the pressure in one air bellows fails, the load-sensing valve automatically moves to a position which approximately corresponds to half the pressure in the intact actuating circuit. If the pressure drops in both air bellows, the small pressure spring (k) in the ram cylinder moves the working piston to the right to the point where the tappet is automatically taken through the dip onto the radial cam. The output pressure then roughly corresponds to half the service braking pressure of the fully laden vehicle.

Test connection 43 allows the load-sensing valve to be checked on the vehicle. For this purpose, the piston valve is pressurized with the preset test pressure while the pressure of the air bellows are automatically separated from the load-sensing valve.



### Automatic Load Sensing Valve 475 720 . . . 0

#### Purpose:

Automatic control of the brake force depending on the spring deflection and thus on the load of the vehicle. By the integrated relay valve the brake cylinders are quickly pressurized and vented.

#### Function:

The load sensing valve is fixed on the vehicle frame and connected via a linkage with a fixed point on the axle resp. on the knuckle joint. The distance between the axle and the load sensing valve is the longest in unladen condition, the lever (j) is in its lowest position. When the vehicle is laden, the distance becomes smaller and the lever (j) is moved from its unladen position into full-load direction. The pin (i) which is turned in the same sense with lever (j) moves the rod (q) via cams in the bearing cover (p) and thus the valve tappet (g) into the position corresponding to the load.

The compressed air (control pressure) which is delivered by the brake valve flows via the port 4 into the room A and pressurizes the piston (b). The piston (b) is moved to the left, closes the outlet (d) and opens the inlet (m). The compressed air which is delivered at the port 4 flows into the room C left of the diaphragm (e)

and through the channel F into the room G and pressurizes the active surface of the relay piston (f).

At the same time, compressed air flows via the open valve (a) and the channel E into the room D and pressurizes the right side of the diaphragm (e). This anticipatory control of the pressure eliminates the reduction ratio in partial laden range at small input pressures (up to max. 1,4 bar). When the input pressure increases again, the piston (n) is moved against the force of the spring (o), and the valve closes.

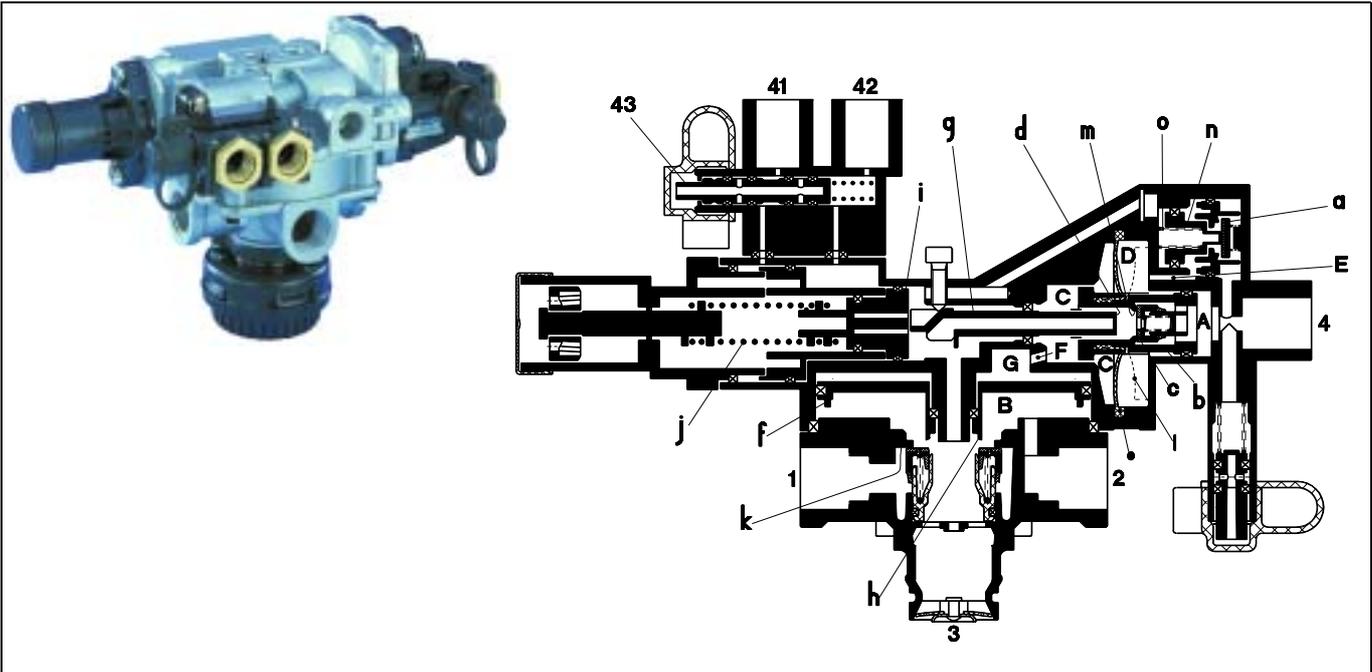
The pressure which builds-up in room G moves the relay piston (f) downwards. The outlet (h) closes and the inlet (k) opens. The supply air at port 1 flows now via inlet (k) into room B and reaches via the ports 2 the subsequent air brake cylinders. At the same time, pressure builds up in room B which acts on the bottom side of the relay piston (f). As soon as this pressure becomes a bit higher than the pressure in room G, the relay piston (f) moves upwards, and the inlet (k) closes.

While the piston (b) is moving to the left, the diaphragm (e) touches the washer (l), and thus increases constantly the active surface of the diaphragm. As soon as the force which acts in room C on the left

side of the diaphragm is identical to the force which acts on the piston (b), piston (b) moves to the right. The inlet (m) closes and a final position is reached.

The position of the valve tappet (g), which depends on the position of the lever (j), is decisive for the active surface of the diaphragm and so for the delivered brake pressure. The piston (b) with the washer (l) must make a stroke corresponding to the position of valve tappet (g), before the valve (c) starts working. This stroke changes the active surface of the diaphragm (e). In full-load position the active surfaces of the diaphragm (e) and the piston (b) have identical size. Thus the pressure delivered at port 4 is delivered in a 1:1 ratio into room C and so also into room G. As the relay piston (f) is pressurized with full pressure, the relay part delivers the pressure 1:1. That means, there is no reduction of the input brake pressure.

After the input pressure at port 4 is exhausted, the pressure in room C moves the piston (b) to the right and the pressure in the ports 2 moves the relay piston (f) upwards. The outlets (d and h) open, and the compressed air escapes to atmosphere via exhaust 3.



## Automatic Load Sensing Valve 475 721 . . . 0

### Purpose:

Automatic control of the brake force depending on the bellows pressure and thus on the load of the vehicle. The integrated relay valve assures quick pressurizing and venting of the brake cylinders.

### Function:

The load sensing valve is controlled by the pressure of the two circuits of the bellows via ports 41 and 42. The control piston (i) which is pressurized by the bellows pressure moves the valve tappet (g) against the force of the spring (j) into the position corresponding to the load. Thus the average value of the bellows pressures 41 and 42 is effective.

The compressed air delivered from the brake valve (control pressure) flows via port 4 into room A and pressurizes piston (b). Piston (b) is moved to the left, closes outlet (d) and opens inlet (m). The compressed air delivered at port 4 flows into room C left of the diaphragm (e), as well as through channel F into room G and pressurizes the active surface of the relay piston (f).

At the same time, compressed air flows via the open valve (a) and channel E into room D and pressurizes the right side of the diaphragm (e). This anticipatory control of the pressure eliminates the reduc-

tion in the partial laden range at small input pressures (up to max. 1,4 bar). When the input pressure increases again, the piston (n) is moved against the force of the spring (a) and the valve closes.

The pressure which builds-up in room G moves the relay piston (f) downwards. The outlet (h) closes and the inlet (k) opens. The supply air at port 1 flows now via inlet (k) into room B and reaches the subsequent air brake cylinders via the ports 2. At the same time, pressure builds up in room B which acts on the bottom side of the relay piston (f). As soon as this pressure becomes a bit higher than the pressure in room G, the relay piston (f) moves upwards and the inlet (k) closes.

While the piston (b) is moving to the left, the diaphragm (e) touches the washer (l), and thus increases constantly the active surface of the diaphragm. As soon as the force which acts in room C on the left side of the diaphragm, is identical to the force which acts on the piston (b), piston (b) moves to the right. The inlet (m) closes and a final position is reached.

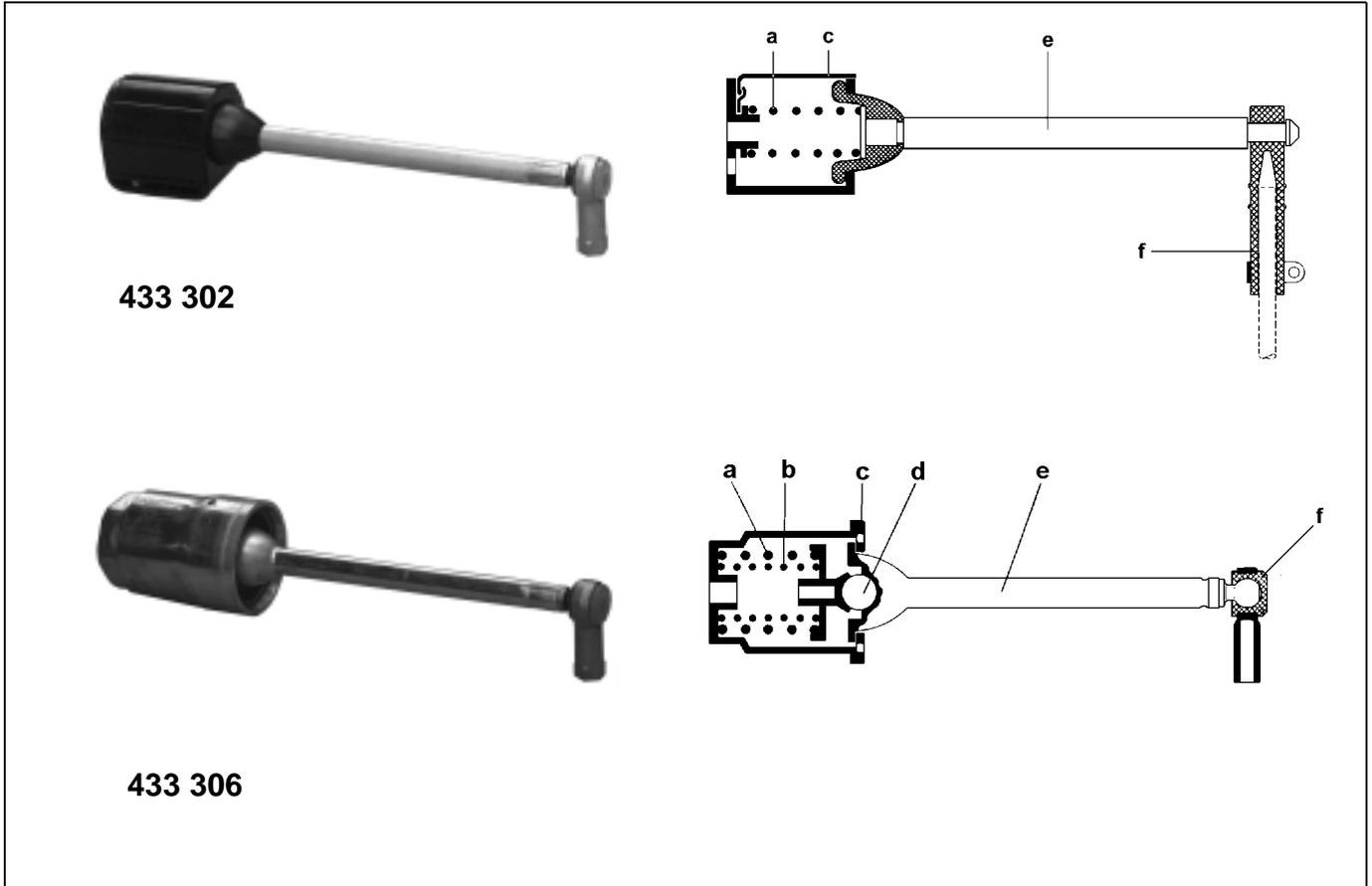
The position of the valve tappet (g), which depends on the position of the control piston (i), is decisive for the active surface of the diaphragm and thus for the delivered brake pressure. The piston (b)

with the washer (l) must make a stroke which corresponds to the position of the valve tappet (g), before the valve (c) starts working. This stroke changes also the active surface of the diaphragm (e). In full-load position the active surfaces of diaphragm (e) and piston (b) have the same size. Thus the pressure delivered at port 4 is delivered in 1:1 ratio into room C and so also into room G. As the relay piston (f) is pressurized with full pressure, the relay part delivers the pressure 1:1. The delivered brake pressure is not reduced.

After the control pressure at port 4 is exhausted, the pressure in room C moves the piston (b) to the right and the pressure in the ports 2 move the relay piston (f) upwards. The outlets (d and h) open and the compressed air escapes to atmosphere via exhaust 3.

If one bellows pressure fails, the valve moves automatically into a position which corresponds to approx. half the pressure of the intact control circuit. If both bellows pressures fail, the valve moves automatically into unladen position.

The test valve with port 43 makes it possible to check the load-sensing valve in the vehicle. For this the control circuits 41 and 42 are pressurized via the test hose while the bellows pressures are separated from the valve by connecting the test hose.



**Knuckle Joint**  
**433 302 . . . 0 and**  
**433 306 . . . 0**

**Purpose:**

To prevent damage to the automatic load sensing valve.

**Operation:**

In the event of large axle movements in excess of the range of movement of the automatic load sensing valve, arm (e), which is horizontal while at rest, is deflected about a fixed point in housing (c). Pressure springs (a) and (b) exert pressure on ball (d) providing constant tensional contact with housing (c) until arm

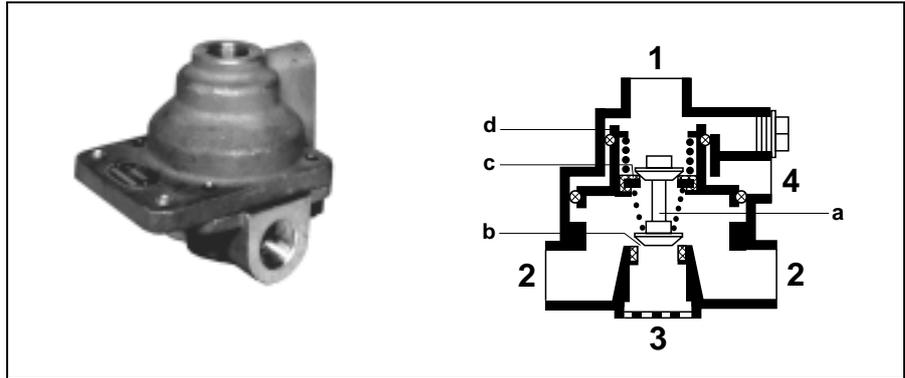
(e) again returns to its normal horizontal position where it is again in full contact with the front face of the housing.

Deformation of the connecting linkage to the automatic load sensing valve is prevented by a ball joint (f) or the rubber thrust member attached to arm (e).

# 1.

## Empty / Load Valve and Pressure Reducing Valve

### Empty / Load Valve 473 300 . . . 0



#### Purpose:

To control the braking force at the front axle of trucks or truck-tractors in response to the load-sensing valve on the rear axle, as well as to provide for the quick release of air from the brake chambers.

#### Operation:

During braking, output pressure from the dual-brake valve passes through port 1 to the upper side of the step piston (d), pushing it downward against its stop. As

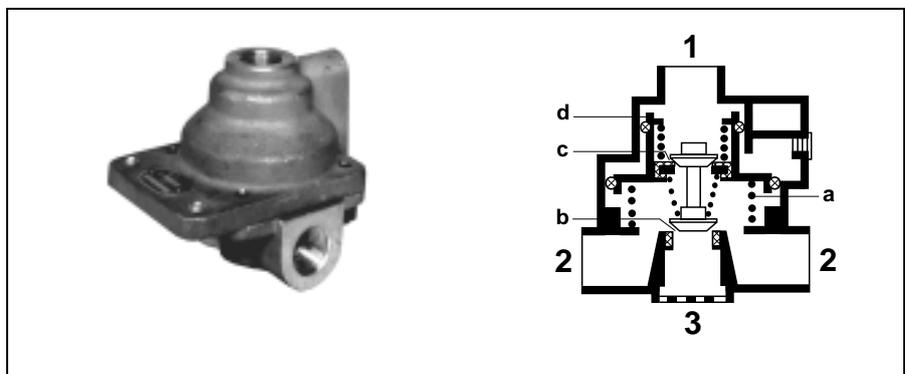
a result, double valve (a) closes outlet (b) and opens inlet (c), thus permitting input pressure to flow through ports 2 to the brake chambers.

Simultaneously, changes in output pressure (effected by the load condition of the vehicle) are directed by the load-sensing valve on the rear axle, thru port 4, onto the ring surface of step piston (d). Inlet (c) closes whenever the ratio between the input pressures (ports 1 and 4) and output pressures (ports 2) is equivalent

to the aspect ratio of step piston (d).

Whenever the control pressures at ports 1 and 4 drop, the higher brake chamber pressure raises piston (d) and double valve (a). Outlet (b) then opens to a degree determined by the control pressure, and a partial or complete the quick release of air from the brake chamber occurs via exhaust 3.

### Pressure Reducing Valve 473 301 . . . 0



#### Purpose:

To reduce the input pressure at a defined ratio and to rapidly reduce the pressure of the downstream components of the braking system.

#### Operation:

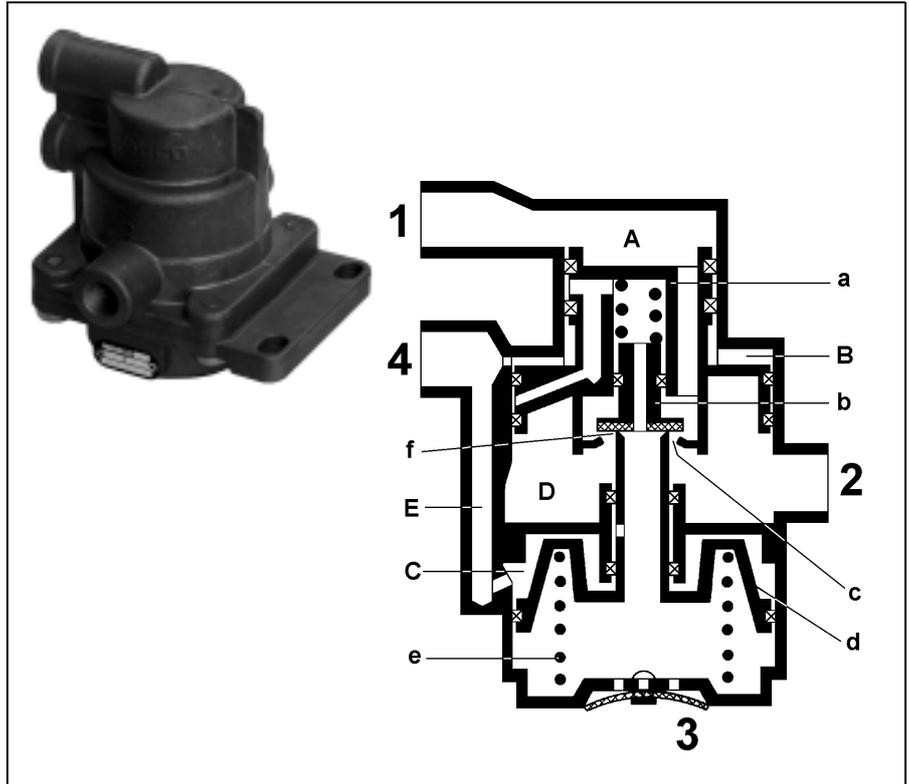
Via Port 1, compressed air flows into Chamber A, forcing differential piston (d) downward against compression spring (a). Outlet valve (b) is closed and inlet valve (c) opened. Via Port 2, the com-

pressed air flows to the downstream components of the braking system.

At the same time, the pressure building up in Chamber B will act on the underside of piston (d). As soon as the forces on the underside and the smaller upper surface of differential piston (d) is balanced, the piston is raised and inlet valve (c) closed. The ratio of the pressures will then be equal to the ratio of the two surfaces of the differential piston.

When the pressure at Port 1 falls, the higher pressure in Chamber B forces differential piston (d) upwards. Outlet valve (b) opens, and the pressure for the downstream components of the braking system will be reduced partially or in full. Compression spring (a) holds the differential piston in its upper final position even if there is no pressure acting on it.

## Empty / Load Valve 473 302 . . . 0



### Purpose:

To control the braking force at the front axle by the rear axle load-sensing valve, as well as to provide for the quick release of air from the brake chambers.

### Operation:

#### **a) Brakes actuated - partially loaded vehicle:**

When the service brake system is actuated, the air pressure controlled by the rear axle ALV is supplied to the brake chambers of the rear axle, and is delivered as control pressure to port 4 of the empty/load valve. This control pressure is transmitted via bore (E) into chamber (C) where it acts upon the upper surface of piston (d) against the force of compression spring (e). At a pressure of 0.5 bar, the piston is lowered to the stopped position. Spring loaded valve (b), moving in conjunction with piston (d), closes inlet (c) and outlet (f) opens. The control pressure also acts in chamber (B) upon the ring-shaped area of piston (a).

Simultaneously, the output pressure of circuit (II) of the tractor brake valve is transmitted via port 1 to chamber (A) and acts upon the top of piston (a). Piston (a)

is moved down, outlet (f) closes, and inlet (c) opens. The compressed air flows via chamber (D) and port 2 into the front axle brake chambers.

The built-up pressure in chamber (D) then moves piston (a) upwards. Inlet (c) closes and a neutral position is reached.

#### **b) Brakes actuated - fully loaded vehicle:**

The operation of the empty/load valve with a fully loaded vehicle is the same as previously described. When the tractor brake valve is actuated, the control pressure acts now with full service brake pressure in chambers (A and B) and the pressure reduction is interrupted. The input to output pressure ratio through the entire range of brake pressures is in this case 1 :1.

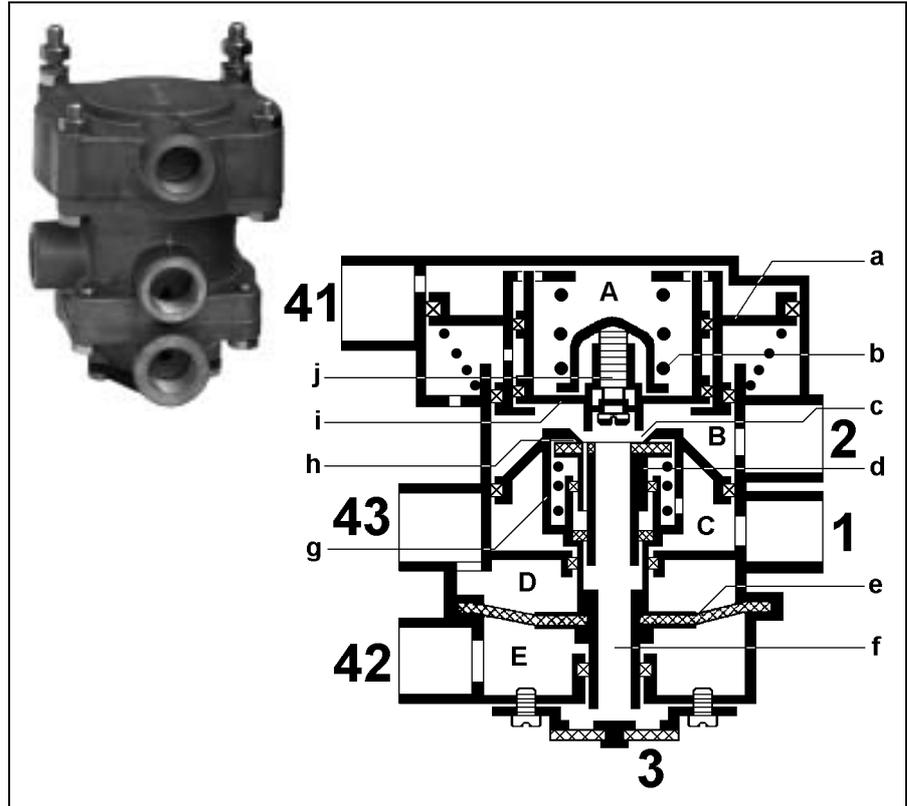
When exhausting the brake system, pressure at ports 1 and 4 decreases via the dual-circuit brake valve. Simultaneously, the brake pressure in chamber (D) moves piston (a) upwards. Inlet (c) closes and outlet (f) opens, and the brake chambers connected to port 2 are exhausted via exhaust port 3.

Piston (d) remains in its lower stop position until pressure at port 4 drops to 0.5 bar. With further pressure decrease in chamber (C), compression spring (e) then moves piston (d) upwards. Outlet (f) closes and inlet (c) opens, and the remaining pressure in port 2 is exhausted via port 1.

#### **c) Operation when the rear axle brake circuit fails:**

If the rear axle brake circuit fails, port 4 and chamber (C), above piston (d), remain without pressure when the service brake system is actuated. The force of compression spring (e) keeps piston (d) in its upper stop position. Inlet (c) remains constantly open. Compressed air from the service brake circuit (II) of the dual-circuit tractor brake valve, flows without limitation through the empty/load valve to the front axle brake chambers.

### Trailer Control Valve with predominance 973 002 . . . 0



#### Purpose:

To control the dual-line trailer brake system, in conjunction with the dual-circuit tractor brake valve and the hand control valve for spring brake actuators.

#### Operation:

##### **a) Control from the dual-circuit tractor brake valve**

Upon actuation of the tractor brake valve, compressed air flows from service brake circuit (I), through port 41, into chamber (A) and pushes down pistons (a and i). When piston (i) comes to rest on valve (d), outlet (c) closes and inlet (h) opens, filling chamber (C). Compressed air passes from chamber (C), through chamber (B), to port 2 and supplies the trailer control line in proportion to service brake circuit (I) pressure with a gain depending upon the pre-set tension of spring (b).

The built-up pressure in chamber (B) acts upon the underside of pistons (a and i). Due to the different operating surface of piston (a), only piston (i) is raised against the control pressure in chamber (A), forcing compression spring (b) upwards. The sequential action of valve (d) closes inlet (h), and a neutral position is reached. With full brake application,

however, the pressure on the upper side of piston (i) is predominant and inlet (h) remains open.

The pre-set tension of compression spring (b) can be changed by turning the adjusting screw (j) until the pre-set pressure gain of port 41, in relation to port 2, reaches 1 bar maximum.

Simultaneous to the operations taking place in port 41, service brake circuit (II) supplies chamber (E), beneath diaphragm (e), with compressed air through port 42. However, due to the filling of chamber (B and D), the pressure above piston (g) and diaphragm (e) predominates and the position of piston (g) does not change. If service brake circuit (I) fails, port 42 is supplied with compressed air through circuit (II). The pressure in chamber (E), beneath diaphragm (e), moves piston (g) and valve (d) upwards. Piston (i), now in its upper end position, closes outlet (c) and opens inlet (h) so that the trailer control line receives compressed air proportional to the tractor brake application.

With partial brake application, piston (g), after pressure build-up in chamber (B), moves downwards, inlet (h) closes and a

neutral position is reached. With full brake application, the pressure in chamber (E) predominates and inlet (h) remains open.

When controlled through circuit (II) of the service brake system, the trailer brake valve operates without predominance.

##### **b) Control from the hand control valve**

The progressive evacuation of the spring brake actuators through the hand control valve brings about a corresponding evacuation of chamber (D) through port 43. The supply pressure, now predominant in chamber (C), moves piston (g) upwards. The supply of air to port 2 then takes place in the same way as for the control of chamber (E) in the event of failure of service brake circuit (I).

After completion of the braking action, ports 41 and 42 are exhausted, and port 43 is re-pressurized. The pressure in chamber (B) causes pistons (a and i) and piston (g) to return to their original positions. Outlet (c) opens and the compressed air in port 2 is exhausted through the hollow piston body (f) and exhaust port 3 to the outside.

## Trailer Control Valve with 2/2 Way Valve and without predominance 973 002 5 . . 0

### Purpose:

To control the dual line trailer brake system, in conjunction with the dual circuit tractor brake valve and the hand control valve for spring brake actuators.

If the trailer control line breaks or is disconnected, and the tractor brake valve is applied, the supply of air from the tractor to the trailer is restricted by the 2/2 way valve; simultaneously, pressure in the trailer supply line is exhausted.

### Operation:

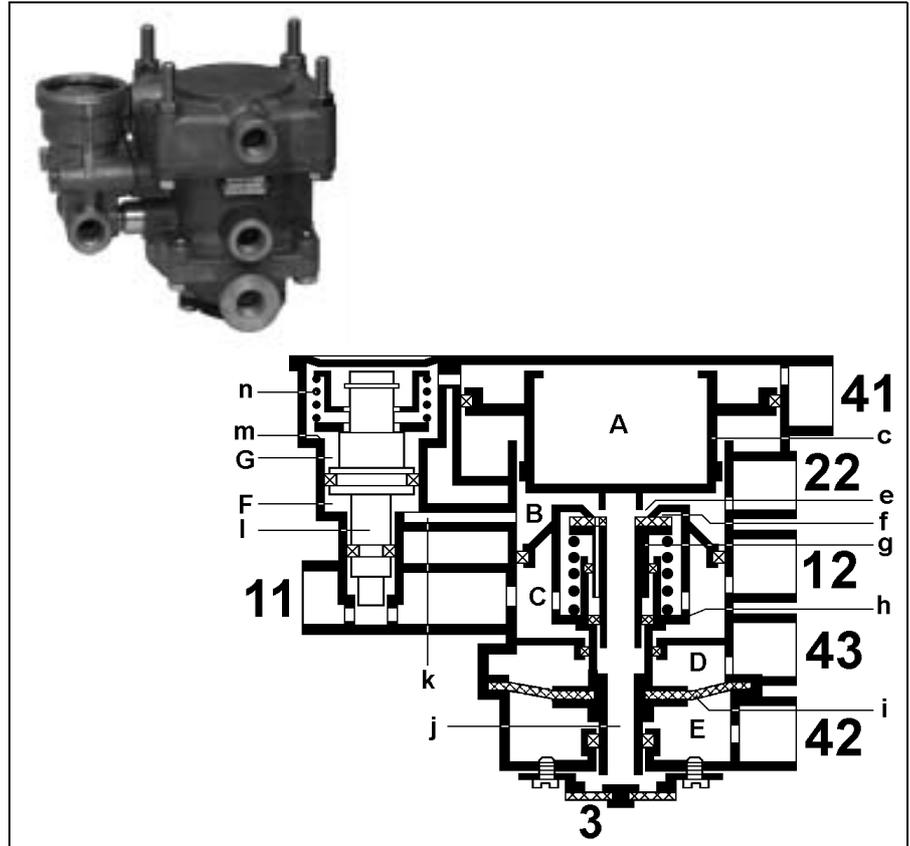
While the air brake system is filling, supply air passes through port 11 into the 2/2 way valve and acts upon piston (l). Piston (l) is moved against the force of the spring (n) into its upper position. Supply air passes through chamber (C) and port 12 to the automatic hose coupling.

#### a) Control from the dual circuit tractor brake valve

Upon actuation of the tractor brake valve, compressed air flows from the service brake circuit 1, through port 41, into chambers (A) and (G) and pushes down pistons (c and l). Pistons (c) are pushed down at the same time. When piston (c) comes to rest on valve (g), outlet (e) closes and inlet (f) opens. Compressed air passes from chamber (B), through chamber (C), to port 22 and supplies the trailer control line in proportion to the service brake circuit 1 pressure.

At the same time as the aforementioned operations are proceeding, compressed air flows through channel (k) into chamber (F) and acts upon the underside of piston (l). At a control pressure of approximately 4 bar, the compressed air above piston (l) predominates, moving the piston downwards until it stops at the housing edge (m). This movement is designed to keep piston (l) from seizing.

The pressure building up in chamber (B) acts upon the undersides of pistons (c) and moves this upwards against the control pressure acting in chamber (A). The sequential action of valve (g) closes inlet (f) and a neutral position is reached. With full brake application, however, the pressure above piston (c) is predominant and inlet (f) remains open.



Simultaneous to the operations taking place at port 41, service brake circuit 2 supplies chamber (E), beneath the diaphragm (i), with compressed air through port 42. However, due to the filling of chambers (B and D), the pressure above piston (h) and diaphragm (i) predominates, and the position of piston (h) does not change. If service brake circuit 1 fails, port 42 is supplied with compressed air through circuit 2. The pressure in chamber (E), beneath diaphragm (i), moves piston (h) and valve (g) upwards. Piston (c), now in its upper end position, closes outlet (e) and opens inlet (f) so that the trailer control line receives compressed air proportional to the tractor brake application.

With partial brake application, piston (h), after pressure build up in chamber (B), moves downwards, inlet (f) closes, and a neutral position is reached. With full brake application, the pressure in chamber (E) predominates and inlet (f) remains open.

When controlled through circuit 2 of the service brake system, the trailer brake valve operates without gain.

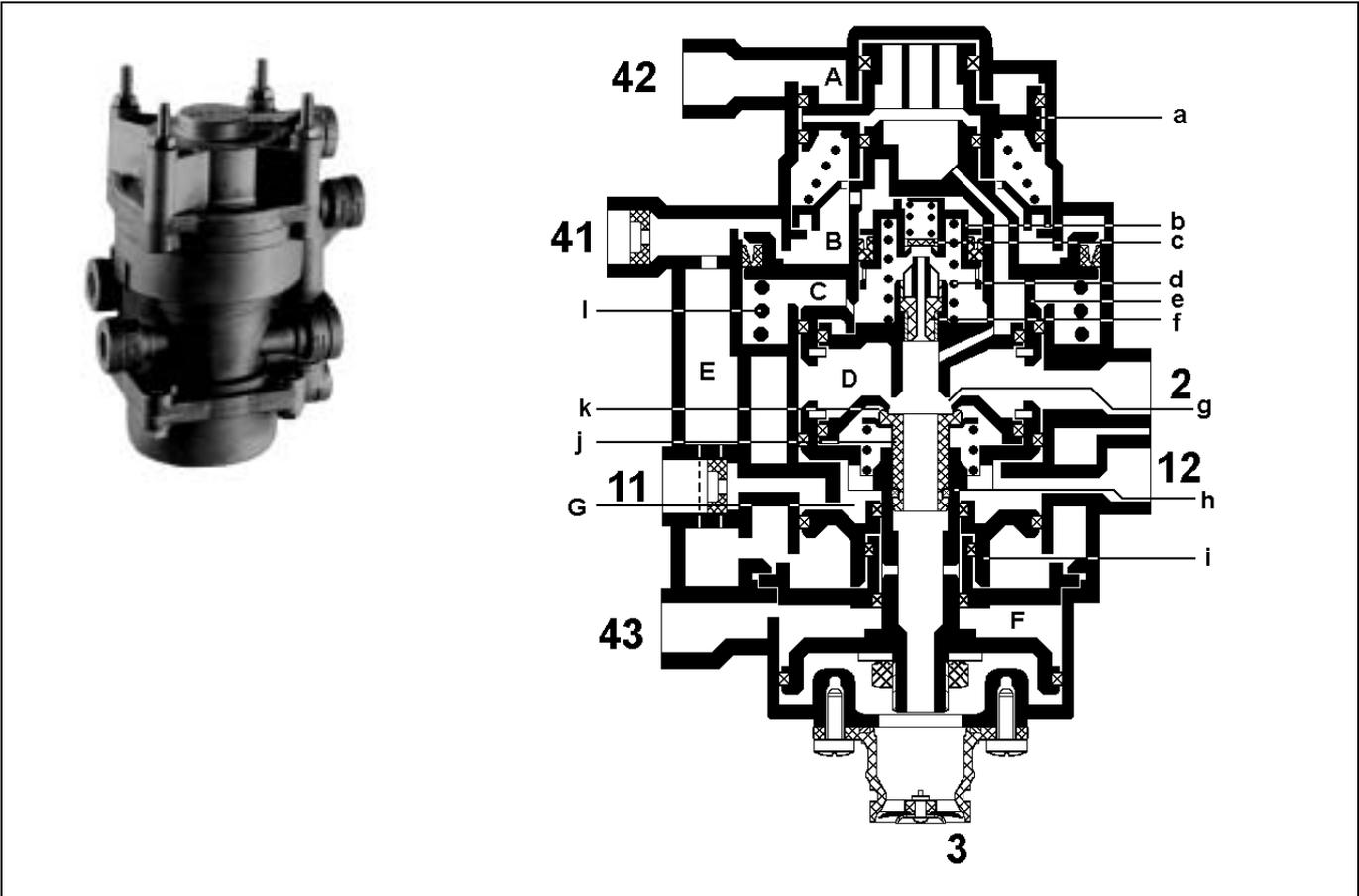
If the trailer control line (connected to port 22) breaks while the service brake

system is actuated, no pressure build up occurs in chambers (B and F). The control pressure in chamber (G) moves piston (l) downwards, and the flow from port 11 to port 12 is partially restricted. At the same time, pressure in the trailer supply line (port 12) exhausts through open inlet (f) and through the trailer control line rupture, and causes automatic trailer braking.

#### b) Control from the hand control valve

The progressive evacuation of the spring brake actuators through the hand control valve brings about a corresponding evacuation of chamber (D) through port 43. The supply pressure, now predominant in chamber (C), moves piston (h) upwards. The supply of air to port 22 then takes place in the same way as for the control of chamber (E) in the event of failure of service brake circuit 1.

After completion of the braking action, ports 41 and 42 are exhausted, and port 43 is repressurized. The pressure in chamber (B) causes pistons (c and h) to return to their original positions. Outlet (e) opens and the compressed air in port 22 is exhausted through the hollow piston body (j) and exhaust port 3 to the outside.



**Trailer Control Valve with predominance 973 008 . . . 0**

**Purpose:**

To control the trailer's twin-line braking system together with the dual-circuit brake valve and the hand brake valve for spring-brake actuators.

If a line ruptures, or the trailer's control line has not been connected, actuation of the brake valve on the motor vehicle will cause a reduction of the air supply from the towing vehicle to the trailer and a simultaneous pressure reduction in the trailer's supply line.

**Operation:**

**a) Actuation from the dual-circuit brake valve**

When the brake valve on the motor vehicle is actuated, compressed air flows from service braking Circuit 1 through Port 41 into Chamber B, acting on piston (e). This moves downwards, closing the outlet (g) and opening the inlet (k) as it sits on the valve (j). The air supply from Port 11 flows through Chamber G to Port 2 and pressurizes the trailer's control line, the pressure being similar to that in

service brake Circuit 1, with a predominance (1 bar max.) set by means of the adjuster screw (f).

The pressure building up in Chamber D acts on the underside of piston (e). Due to the difference in the effective areas of piston (e), the actuating pressure in Chamber C and the force of the pressure spring (I) causes that piston to move upwards. The valve (j) following piston (e) closes the inlet (k) and a neutral position has been reached. At full brake application, the pressure acting on the upper side of piston (e) is greater and the inlet (k) remains open.

When the pressure in Chamber B is increased, piston (b) is forced downwards against the pressure of the control spring (d). The valve (c) is opened by the adjuster screw (f) and the actuating pressure then building up in Chamber C supports the downward control of piston (e). This can cause the output pressure at Port 2 to be lower than the actuating pressure at Port 41. When the adjuster

screw (f) is turned anti-clockwise, for instance, the pressure in Chamber C is reduced, and to maintain the balance, the output pressure is increased.

Simultaneously with the processes at Port 41, Chamber A is pressurized from the service braking circuit through Port 42. Since, however, the force generated by pressurizing Chambers B and C which acts on the upper side of piston (e) is greater, the position of piston (a) is irrelevant. If a defect causes the service braking Circuit 1 to fail, only Port 42 is pressurized from Circuit 2. The pressure thus building up in Chamber A forces piston (a) downwards and pushes piston (e) ahead, and the trailer's control line receives its pressure as described above, albeit without any predominance.

### ***b) Actuation from the hand brake valve***

The graded evacuation of the spring-brake actuators through the hand brake valve causes the pressure in Chamber F to be reduced accordingly through Port 43. The supply pressure at Port 11 now being higher forces piston (h) upwards. Port 2 is then pressurized as for Chamber A if service braking Circuit 1 fails.

When the braking process is ended, Ports 41 and 42 are evacuated again, or Port 43 pressurized. This causes pistons (a and e), and piston (h) (by the pressure in Chamber D) to return to their original positions. Outlet (g) opens and the com-

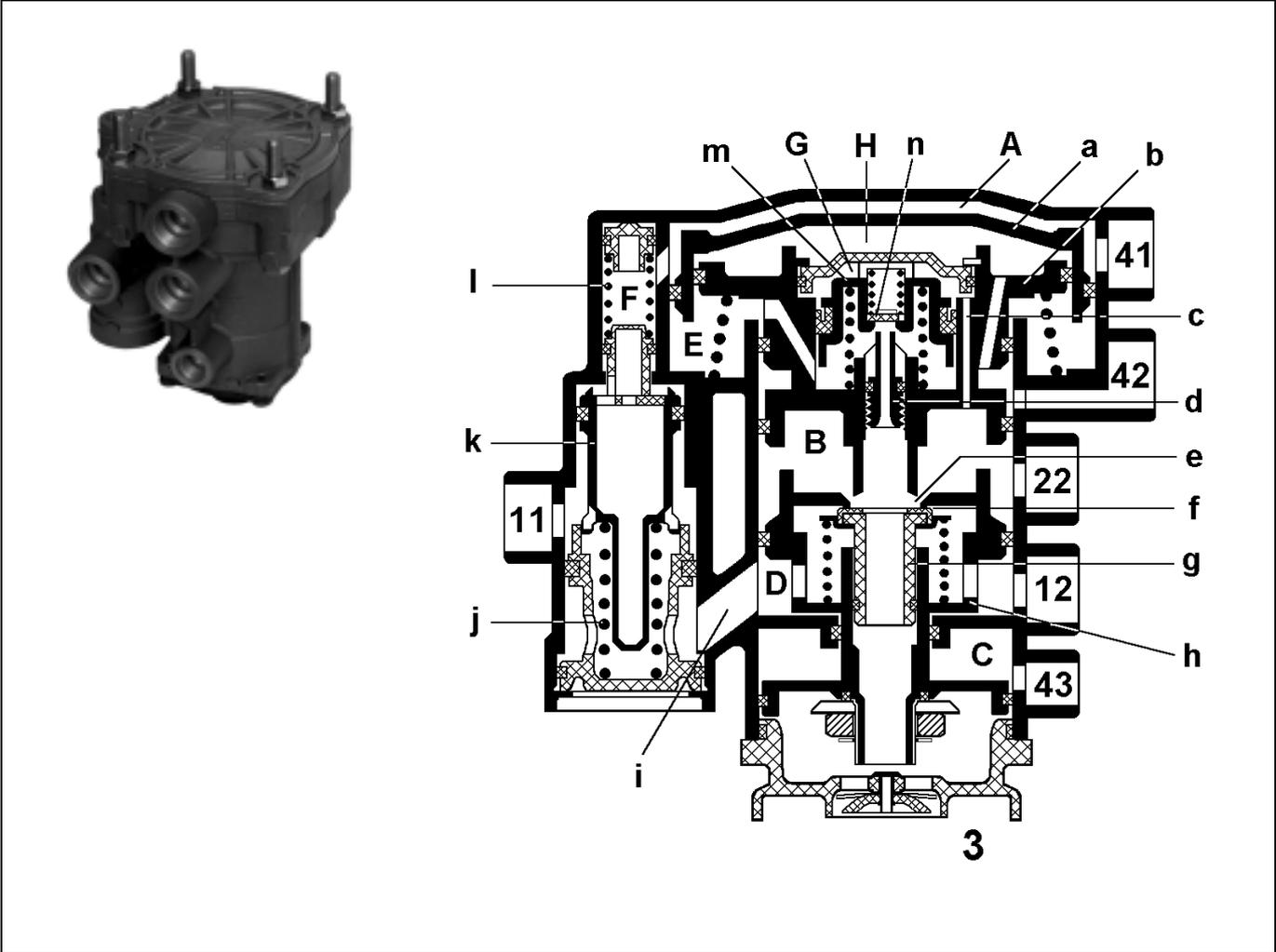
pressed air in Port 2 is evacuated to atmosphere through the tubular piston (h) and Vent 3.

### ***c) Safeguard Against Rupture Of The Pilot Line***

When the braking system is being filled with compressed air, the air supply flows through Port 11 and Chamber G to Port 12 and from there to the automatic 'Supply' hose coupling.

When the brakes are actuated, an actuating pressure is built up through Port 2 in the line leading to the 'Control' hose coupling, the required air being fed in from Port 11. This causes the pressure above the piston (3) to fall slightly. At the same time, compressed air from Port 41 is fed beneath piston (i) through Duct E. The pressure in Chamber G rises again, causing the piston to be forced downwards (play motion to prevent piston (i) from getting stuck).

If a rupture of the trailer's control line prevents pressure building up at Port 2, piston (i) remains in its upper position and blocks the passage leading to Chamber G. The air supply from Port 11 to Port 12 is throttled and the pressure in the trailer's supply line (Port 12) is reduced through the open inlet (k) at the point of rupture in the trailer's control line, thus causing automatic braking of the trailer.



**Trailer Control Valve with predominance and 2/2 Way Valve 973 009 . . . 0**

**Purpose:**

To control the trailer's twin-line braking system together with the dual-circuit brake valve and the hand brake valve for spring-brake actuators.

If a line ruptures, or the trailer's control line has not been connected, actuation of the brake valve on the motor vehicle will cause a reduction of the air supply from the towing vehicle to the trailer and a simultaneous pressure reduction in the trailer's supply line. This process causes immediate automatic braking of the trailer.

**Operation:**

When the braking system is being filled with compressed air, the air supply flows through Port 11 into the 2/2-way valve and acts on piston (k). This is forced upwards into its upper neutral end position against the force of pressure spring (l) and supported by the pressure spring (j). Through duct (i), the air supply flows into Chamber D to Port 12 and from there

through Port 12 to the automatic 'Supply' hose coupling.

**a) Actuation from the dual-circuit brake valve**

When the brake valve on the motor vehicle is actuated, compressed air flows from service braking Circuit 1 through Port 41 into Chambers A and F, acting on pistons (a and k). Piston (a) moves downwards, forcing piston (b) down. As piston (b) sits on the valve (g), the outlet (e) is closed and the inlet (f) is opened. The air supply flows through Chamber B to Port 22 and pressurizes the trailer's control line, the pressure being similar to that in service brake Circuit 1, with a predominance of  $0.2 \pm 0.1$  bar, this being adjustable by means of the adjuster screw (d).

At the same time, compressed air flows into Chamber G through the hole (c), moving piston (m) against the force of the spring. The valve (n) sits on the adjuster screw (d), opening the passage to

Chamber E. The air flows into Chamber E and supports the forces acting on the underside of piston (b).

The pressure building up in Chambers B and E acts on the different effective areas of piston (b), pushing it upwards, together with piston (a), against the actuating pressure in Chamber A. The valve (g) following pistons (b and a) closes the inlet (f) and a neutral position has been reached. At full brake application, the pressure acting on the upper side of piston (a) is greater and the inlet (f) remains open.

Simultaneously with the processes at Port 41, Chamber H above piston (b) is pressurized from the service braking circuit through Port 42. Since, however, the force generated by pressurizing Chamber A which acts on the upper side of piston (a) is greater, the position of pistons (a and b) does not change.

If a defect causes the service braking Circuit 1 to fail, only Port 42 is pressurized from Circuit 2. The pressure thus building up in Chamber H beneath piston (a) forces piston (b) downwards. This closes the outlet (e) and opens the inlet (f), and the trailer's control line is pressurized accordingly, albeit without any predominance.

Within the range of partial brake application, the pressure building up in Chambers B and E pushes piston (b) upwards once again. The inlet (f) closes and a neutral position has been reached. At full brake application, the pressure in Chamber H is greater and the inlet (f) remains open.

In the event of a rupture of the trailer's control line (Port 22), no pressure builds up in Chambers B and E when the service braking system is actuated. The air is evacuated to atmosphere at the point of rupture through the open inlet (f) and Port 22. This causes piston (k) to be pushed down further by the actuating pressure acting in Chamber F, throttling the supply pressure flowing from Port 11 to Port 22. At the same time, the pressure in the trailer's supply line (Port 12) is reduced through the open inlet (f) at the point of rupture in the trailer's control line, causing automatic braking of the trailer.

### ***b) Actuation from the hand brake valve***

The graded evacuation of the spring-brake actuators through the hand brake valve causes the pressure in Chamber C to be reduced accordingly through Port 43. The supply pressure in Chamber D now being higher forces piston (h) upwards. Port 22 is then pressurized as for Chamber H if service braking Circuit 1 fails.

When the braking process is ended, Ports 41 and 42 are evacuated again, or Port 43 pressurized. This causes pistons (a and be), and piston (h) (by the pressure in Chamber C) to return to their original positions. Outlet (b) opens and the compressed air in Port 22 is evacuated to atmosphere through the tubular piston and Vent 3.

**Wendelflex® -  
Hose Connection  
452 711 . . . 0**



**Purpose:**

- 1) Connection of the air brake system of the tractive unit with that of the semi trailer.
- 2) Connection of sections of the air brake system, which have variable length between themselves.

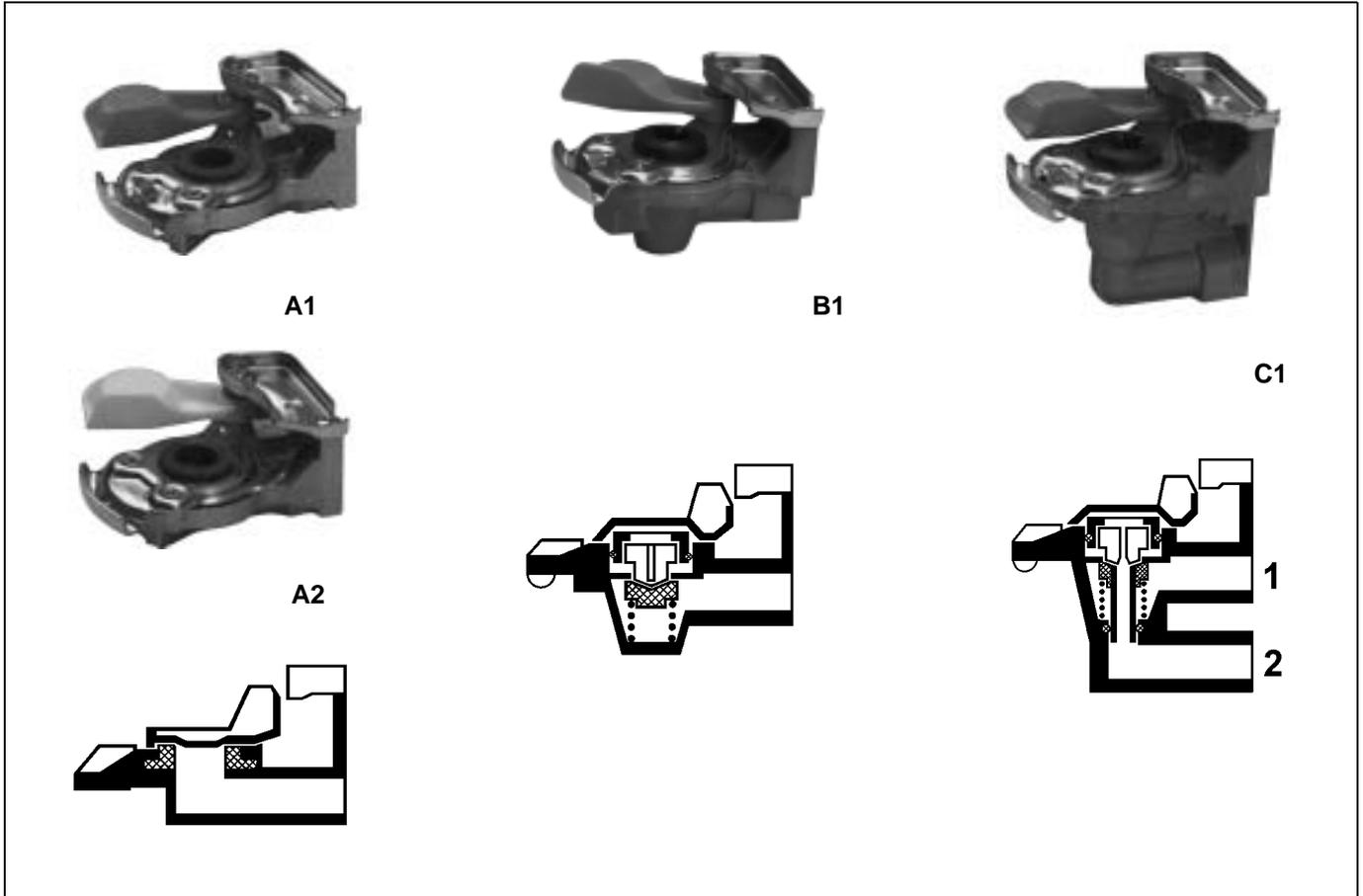
**Construction:**

Wendelflex is a coiled hose, which expands with length alterations and retracts to its original length when released.

From the hose connection to the first coil the hose is stiffened through an in built helical spring which prevents kinking in this susceptible region.

Wendelflex hose connections need no additional gantries or supports. The Wendelflex hose connection is made out of black Polyamid 11. For a visual differentiation of the hose connections the hose couplings are supplied with coloured covers.

Polyamid 11 resists all substances occurring on vehicles such as e.g. petroleum products, oils and greases. The pipes will also withstand alkalis, unchlorinated solvents, organic and inorganic acids and diluted oxydizing agents. (Use of chlorinated cleansing agents is therefore to be avoided). Resistance against special substances can be given on request.



## Coupling Heads for dual line braking system 952 200 . . . 0

### Purpose:

To connect the air brake system of a towing vehicle to a trailer in accordance with EEC regulations. The coupling heads conform to ISO Std. 1728.

### Description:

Coupling head versions A1, B1 and C1 for the supply line have red covers and a centrally cast protrusion to prevent meal coupling, versions A2 and B2 for the service line have a yellow cover and a cast protrusion on one side to prevent meal coupling. Versions B and C are fitted with automatic shut off valves.

### Connecting:

The coupling heads are connected by locating the guides of both couplings and rotating the flexible connected coupling to lock. After locking, a good seal is established between the coupling heads.

The cast protrusions ensure that connections between incorrect couplings are not made (Refer to chart showing various types).

- Coupling C1 with A1, B1 with A1 and B2 with A2.

During coupling the sealing ring of coupling head type A, opens the automatic shut off valve fitted to types B or C. A sealed, through connection is then established. The shutoff valves close automatically when the couplings are disconnected.

- Coupling A2 with A2.

When connecting identical coupling heads without shut off valves, a pressure is established between the sealing rings.

# 1.

## Duo-Matic Quick Coupling

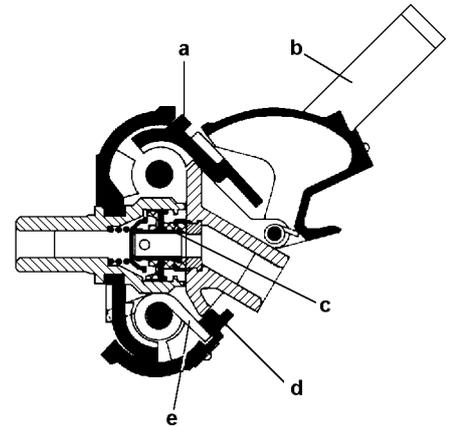
### Duo-Matic Quick Coupling For Trailers 452 80. . . . 0

**Purpose:**

To connect the compressed air braking system of the motor vehicle to that of the trailer.

**Operation:**

When attaching the trailer, handle (b) is pushed downwards; this causes protective caps (a) and (d) to open. The Duo-Matic trailer portion is placed below the protective caps and handle (b) is released. Torsion spring (e) acts upon protective caps (a) and (d), pushing the trailer portion against the automatic closing valves (c), causing them to open. Compressed air now reaches the trailer.



Tractor portion  
452 802 009 0



Trailer portion  
452 804 012 0

### Duo-Matic Quick Coupling For Semi-trailers 452 80. . . . 0

**Purpose:**

To connect the compressed air braking system of the semi-trailer tractor to that of the semi-trailer.

**Operation:**

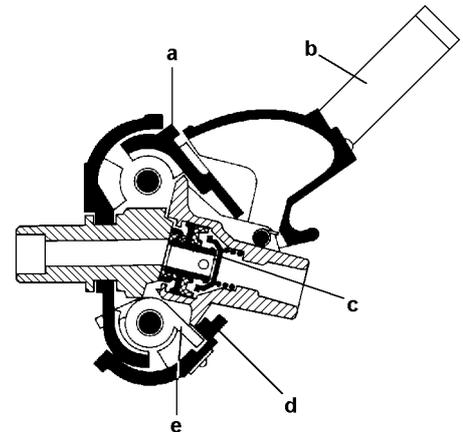
When attaching the semi-trailer, handle (b) is pushed downwards; this causes protective caps (a) and (d) to open. The Duo-Matic tractor portion is placed below the protective caps and handle (b) is released. Torsion spring (e) acts upon protective caps (a) and (d), pushing the tractor portion against the contact surface. The automatic shut-off valves (c) open and compressed air reaches the semi-trailer.



Tractor portion  
452 805 004 0



Semi-trailer portion  
452 803 005 0



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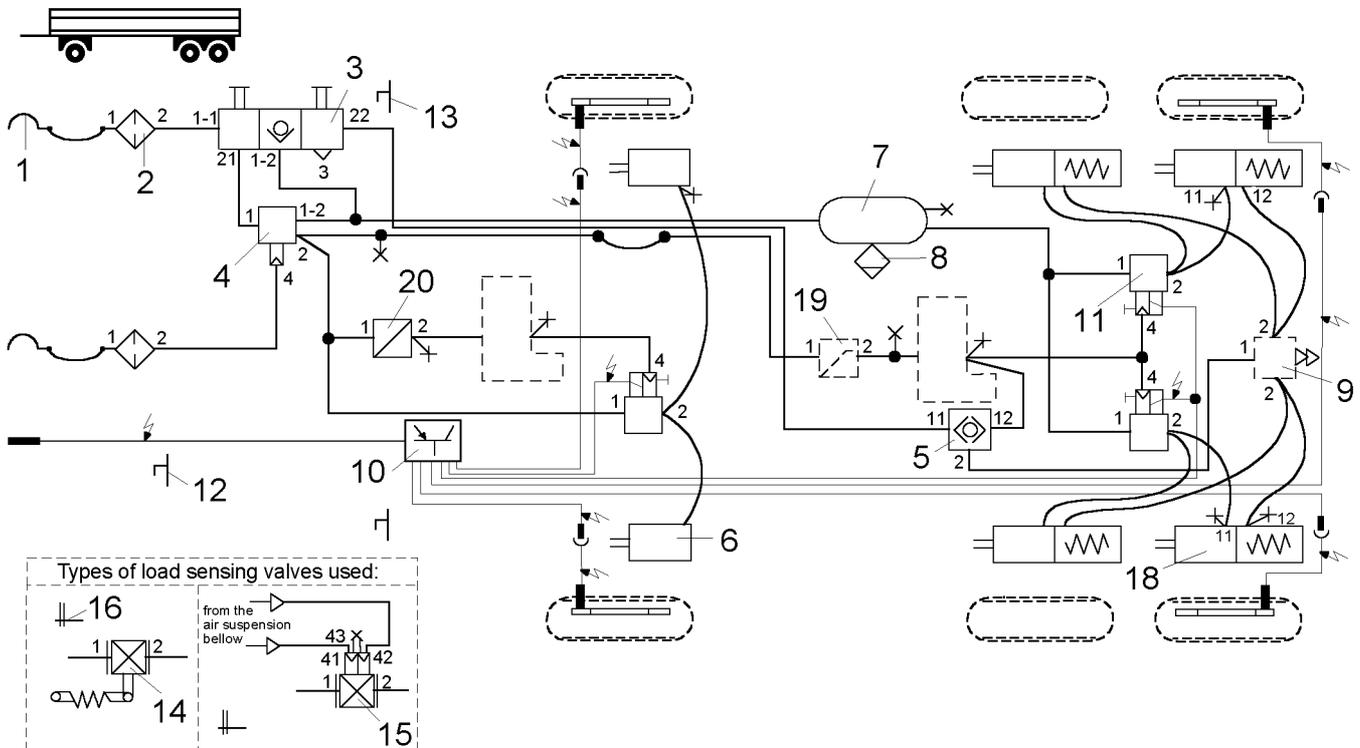
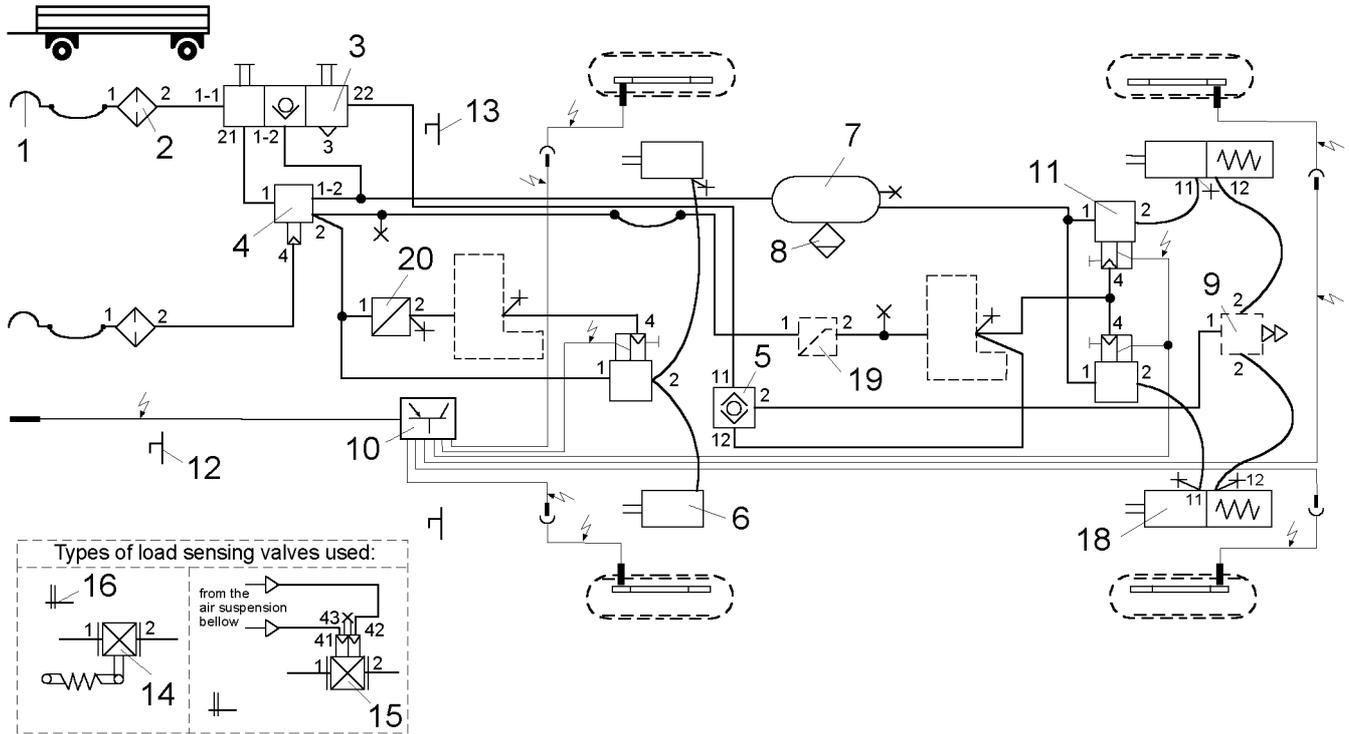
# Equipment For Trailer Braking Systems

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# 2.

## Trailer with twin-line air braking system

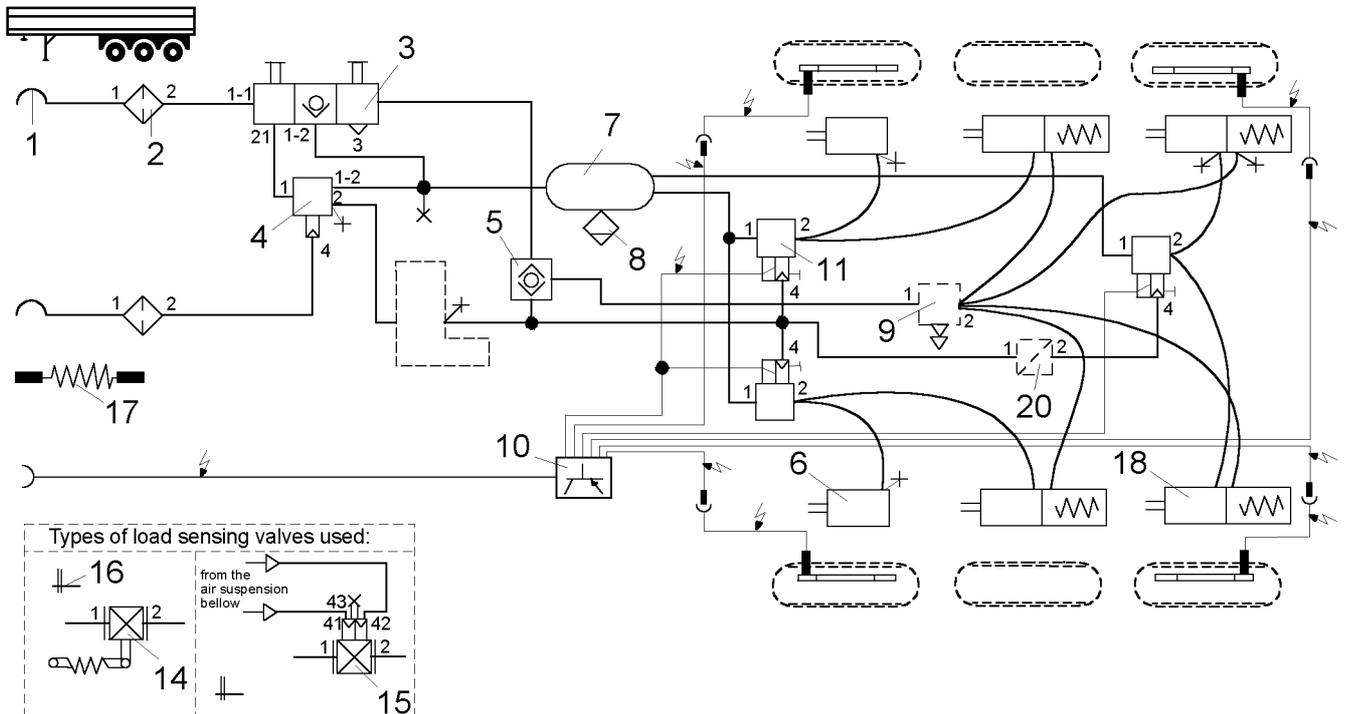
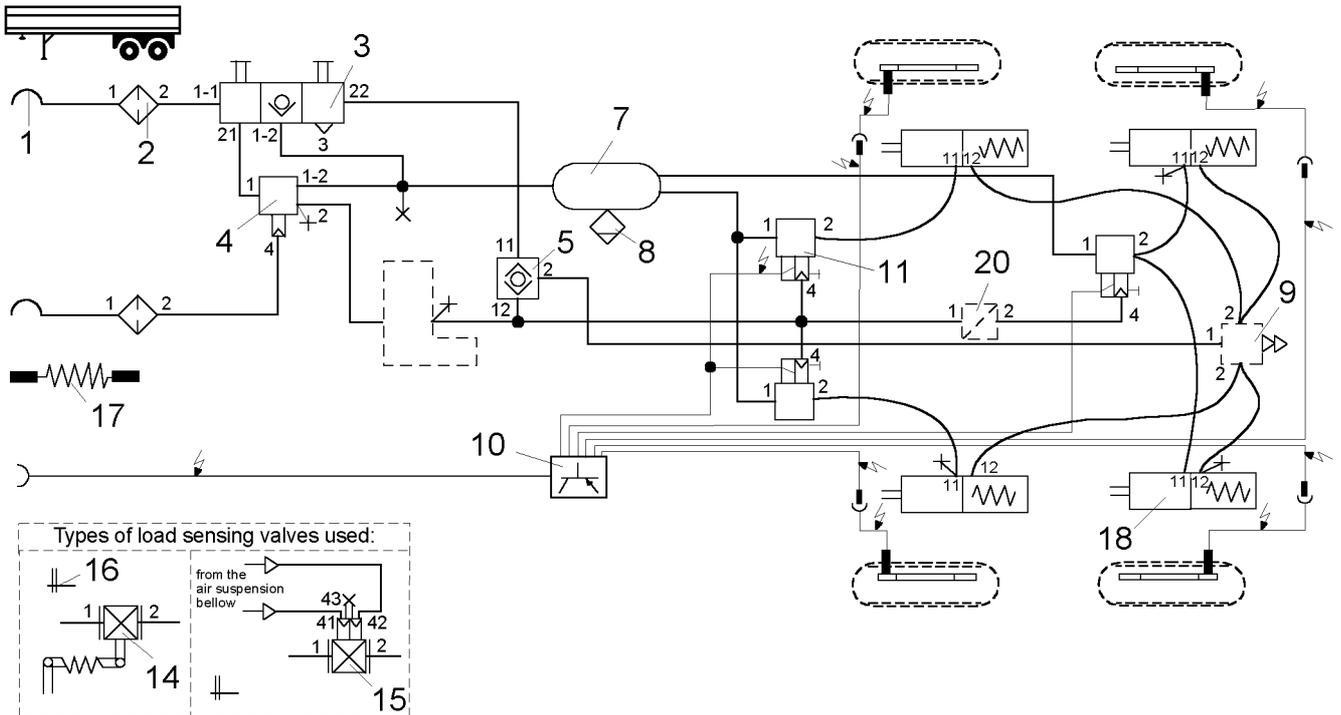
### Trailer complying with the ECE Directive



Council Directive 71/320/EEC of the "European Communities" and ECE Regulation 13 are contained in the manual entitled "Legal Requirements".

This manual is available from our Department AM-M4, Tel. (511) 922 1688 quoting Part Number 815 000 051 3.

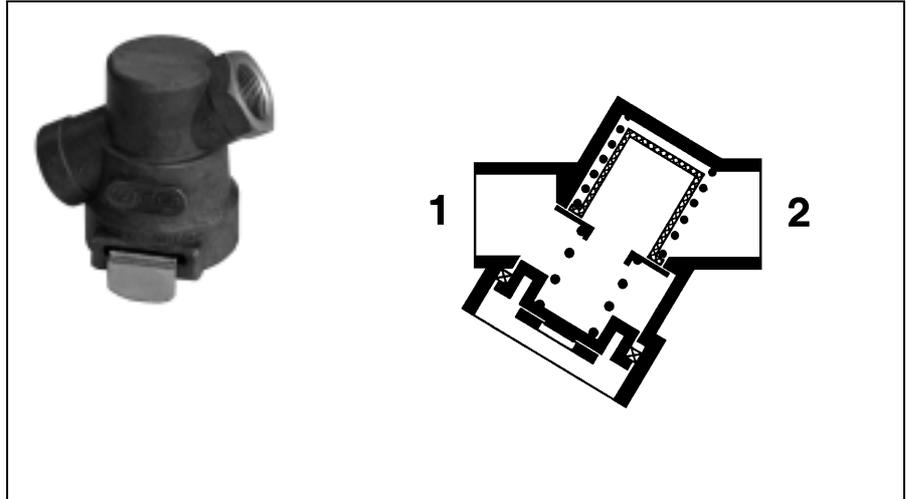
## Semi-trailer complying with the ECE Directive



### Legend:

- |  |  |
|--|--|
| 1. Hose coupling                         | 11. ABS relay valve                                |
| 2. Line filter                           | 12. ABS parking socket                             |
| 3. Double release valve with check valve | 13. Dummy coupling with fastening                  |
| 4. Relay emergency valve                 | 14. Load sensing valve with integral knuckle joint |
| 5. Two-way valve                         | 15. Load sensing valve with integral test valve    |
| 6. Brake Chamber                         | 16. Plate, ALV setting                             |
| 7. Air reservoir                         | 17. ABS-Elektrowendel                              |
| 8. Drain valve                           | 18. Tristop Spring Brake Actuator                  |
| 9. Quick release valve                   | 19. Pressure limiting valve                        |
| 10. ABS electronics                      | 20. Adjusting valve                                |

### Line Filter 432 500 . . . 0



#### Purpose:

To protect the air braking system against dirt.

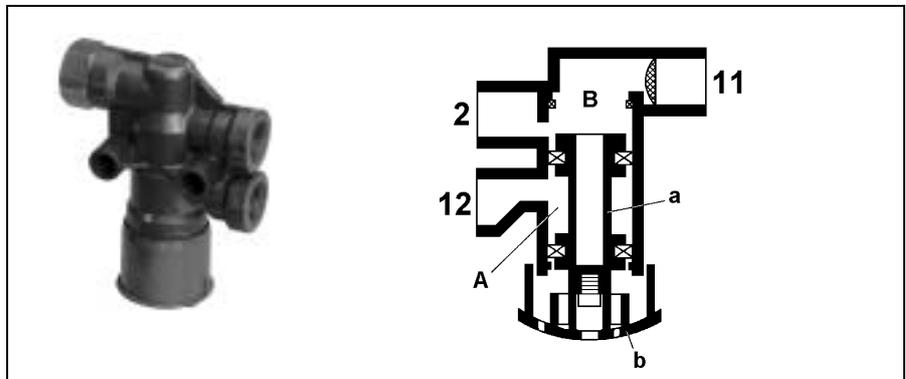
#### Operation:

The compressed air reaching the line filter via port 1 passes through the filter cartridge in which any particles of dirt are retained; the compressed air is cleaned before it reaches any downstream appliances from port 2.

If the line filter is blocked, the filter cartridge is pushed upwards against the force of the pressure spring and the compressed air will pass through the line filter without being cleaned.

If port 1 is exhausted while the filter cartridge is blocked, the pressure in port 2 can push the cartridge downwards against the force of the compression spring. This permits return flow from port 2 to port 1.

### Trailer Release Valve 963 00. . . . 0



#### Purpose:

To release the braking system for the purpose of moving a trailer that is disconnected from the tractor unit. The double release valve has been designed for use in braking systems using Tristop® spring brake actuators.

#### Operation:

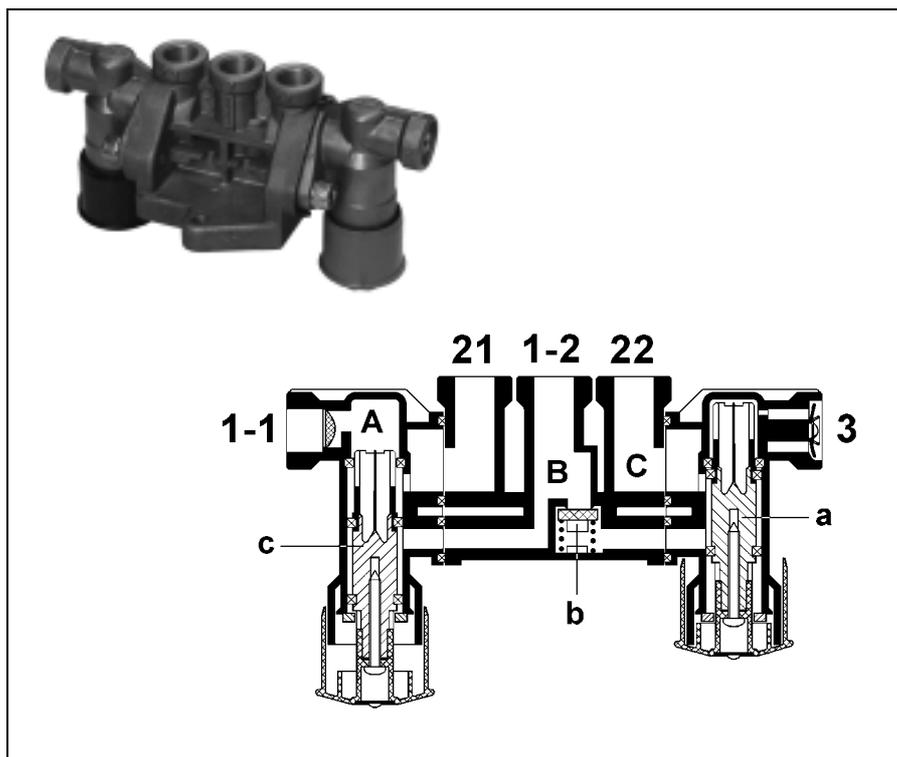
When a semitrailer is connected to the prime mover, air from the supply line flows through port 11 into chamber (B). If piston (a) is still in the release position it is pushed out into the driving position by the supply pressure. The air from the supply line then flows through port 2 to

the relay emergency valve and on to the reservoir on the trailer.

When the trailer is uncoupled, port 11 and therefore chamber (B) are exhausted causing the relay emergency valve to apply the trailer brakes. To release the brakes, piston (a) is pushed home manually using knob (b). This closes the passage from port 11 to port 2 and a connection between chamber (A) and port 2 is established.

The reservoir pressure of the semi-trailer at port 12 flows to the relay emergency valve via port 2, causing it to reverse. The brake actuators are exhausted and the trailer brakes released.

## Trailer Release Valve 963 001 05 . 0



### Purpose:

Releasing the braking system (for systems with Tristop® cylinders) to move unhitched trailers.

### Operation:

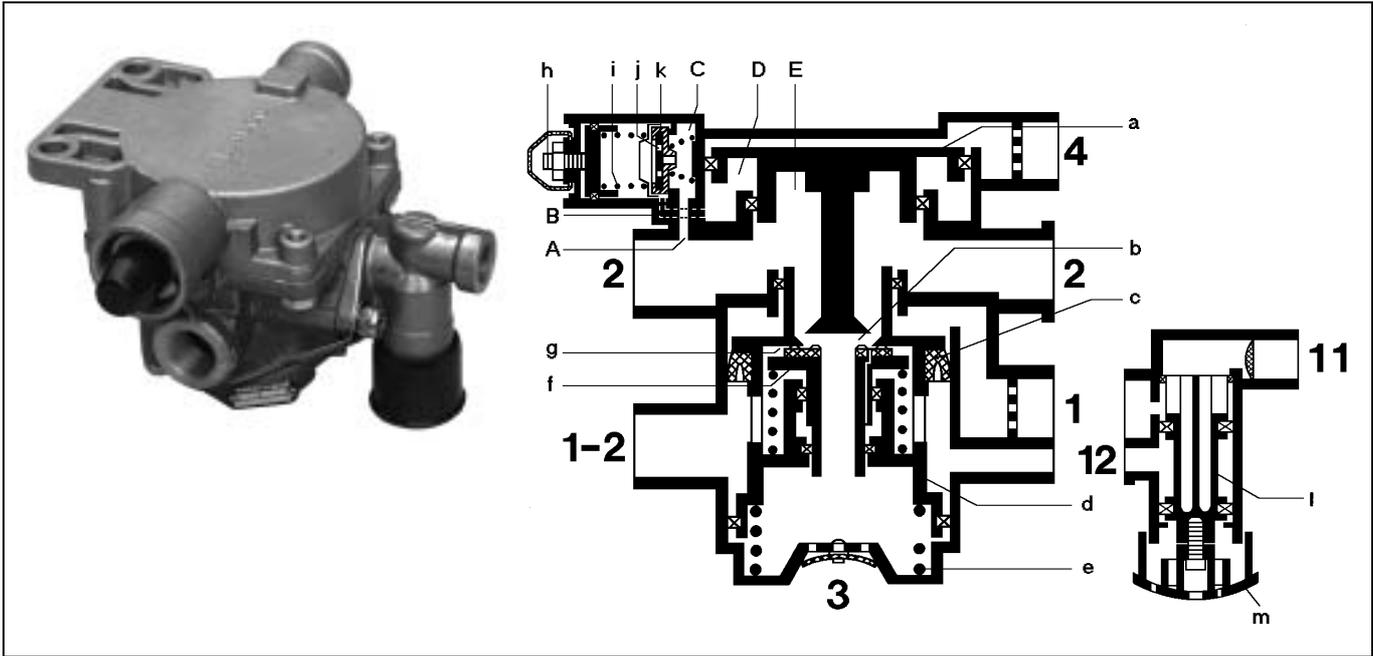
While coupling the trailer onto the vehicle, make sure that the piston (a) is still in parking position; if yes, push it to the driving position. When the coupling head is connected, compressed air flows through port 1-1 into chamber A. If the piston (c) is still in release position, it is pushed out into driving position by the supply pressure. The air supply then passes through port 21 into the relay emergency valve and then into the trailer's air reservoir.

Compressed air flows through port 1-2 into chamber B, opens the check valve (b), passes through chamber C and port 22 into the downstream two-way quick release valve and pressurises the Tristop® cylinder's spring compression chambers.

Pressure in Port 1-1 and, subsequently, chamber A is reduced in the unhitched position. To release the service braking system, use the actuating knob to push the piston (c) until stop. This blocks the passage from port 1-1 to port 21, and a connection is created between chamber A and port 1-2.

The air supply at port 1-2 flows through port 21 into the trailer emergency valve and switches it to driving position, thereby reducing the pressure in the brake cylinder.

The piston (a) is pulled out when the parking brake is activated. The compressed air in chamber C and at port 22 is released into the atmosphere via exhaust 3. The downstream quick release valve reverses and pressure is reduced in the Tristop® cylinder's spring compression chambers.



**Relay Emergency Valve with adjustable predominance**  
**971 002 150 0**  
**and Trailer Release Valve**  
**963 001 012 0**

**Purpose:**

To control the twin-line braking system of a trailer.

**Operation:**

**a) Relay Emergency Valve**

Compressed air passes from the tractor through the supply line hose coupling to port 1, passes grooved ring (c) and continues through port 1-2 to the trailer reservoir.

Upon actuation of the tractor brakes, compressed air flows via the hose coupling in the control line and port 4 to the upper side of piston (a). The piston is forced down and by seating on valve (f) closes outlet (b) and opens inlet (g). Air from the trailer reservoir port 1-2 now flows via ports 2 to the downstream brake valves and into chamber (C) via passage (A). Pressure builds up against valve (k).

As soon as the pressure in chamber (C) predominates, valve (k) opens against the force of pressure spring (i). The air flows into chamber (D) via passage (B),

acting on the underside of piston (a). As a result of the compounding of forces in chambers (D) and (E), the pilot pressure acting on the upper side of piston (a) is overcome and piston (a) is forced up.

In the case of partial brake application, valve (f) closes inlet (g) and a neutral position is reached. In the case of full brake application, inlet (g) is kept open by piston (a) over the entire braking process.

A maximum predominance of 1 bar can be established between ports 2 and 4 by means of adjusting the tension of pressure spring (i) using set screw (h).

When the tractor brakes are released, port 4 is vented and the pressure in ports 2 forces piston (a) upward to the top of its stroke. Inlet (g) is closed and outlet (b) is opened. The compressed air at ports 2 is exhausted to atmosphere through valve (f) and exhaust 3. Due to the drop in pressure in chamber (C), the compressed air in chamber (D) flows via bores (j) of valve (k) into chamber (C) and on to exhaust 3.

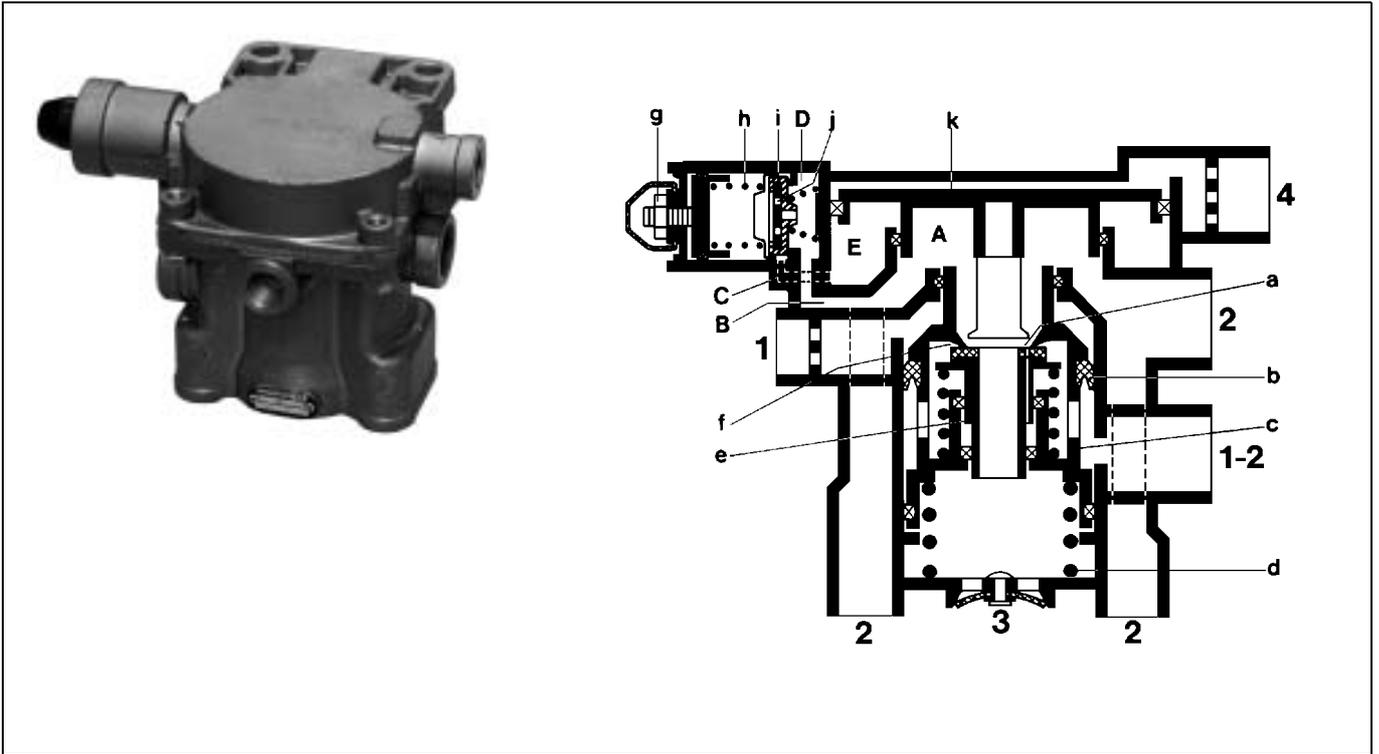
When the trailer is uncoupled or in the event of a rupture in the supply line, port 1 is exhausted and the pressure acting on the upper side of piston (d) is reduced. The load in pressure spring (e) and the supply pressure at port 1-2 forces up piston (d) and valve (f) closes out-

let (b). As piston (d) continues to move up, it moves away from valve (f) and inlet (g) opens. The supply pressure at port 1-2 flows to the downstream brake valves via ports 2 at a 1:1 ratio.

**b) Trailer Release Valve**

If the relay emergency valve is used in combination with automatic load-sensing braking or a manually adjustable load apportioning valve without a release position, Trailer Release Valve 963 001 . . . 0 permits the trailer being moved when uncoupled. For this purpose, piston (l) is pushed home by hand via push (m). This closes the passage from port 11 of the trailer release valve to port 1 of the relay emergency valve and a connection between port 1 of the relay emergency valve and port 12 of the trailer release valve is established. Pressure from the trailer reservoir at port 12 flows through port 1 of the relay emergency valve, causing it to reverse into the driving position. The brake actuators are exhausted.

If piston (l) is not pulled out manually all the way when the trailer is re-coupled, the supply pressure from the motor vehicle will force it out. The release valve is once more in its normal position in which port 11 of the release valve and port 1 of the relay emergency valve are connected.



## Relay Emergency Valve with adjustable predominance 971 002 152 0

### Purpose:

To control the twin-line braking system of a trailer when the braking system of the prime mover is actuated. Automatic braking of the semi-trailer in the event of partial or total loss of pressure in the supply line.

This relay emergency valve should be used particularly in long multi-axle semi-trailers.

### Operation:

#### a) Service Brake Application

Compressed air passes from the prime mover through the supply line hose coupling to port 1, passes grooved ring (c) and continues through port 1-2 to the semi-trailer reservoir. At the same time, compressed air from the supply line forces down piston (c) and valve (e) against the load in pressure spring (d). Outlet (a) opens and ports 2 are connected with exhaust 3.

Upon actuation of the tractor brakes, compressed air flows via the hose coupling in the control line and port 4 to the upper side of piston (k). The piston is forced down and by seating on valve (e) closes outlet (a) and opens inlet (f). Air from the semi-trailer reservoir port 1-2 now flows via ports 2 to the downstream brake actuators and into chamber (D) via passage (B). Pressure builds up against valve (i). As soon as the pressure in chamber (C) predominates, valve (i) opens against the force of pressure spring (h). The air flows into chamber (E) via passage (C), acting on the underside of piston (k). As a result of the compounding of forces in chambers (A) and (E), the pilot pressure acting on the upper side of piston (k) is overcome and piston (k) is forced up.

In the case of partial brake application, valve (e) closes inlet (f) and a neutral position is reached. In the case of full brake application, inlet (f) is kept open by piston (k) during the entire braking process.

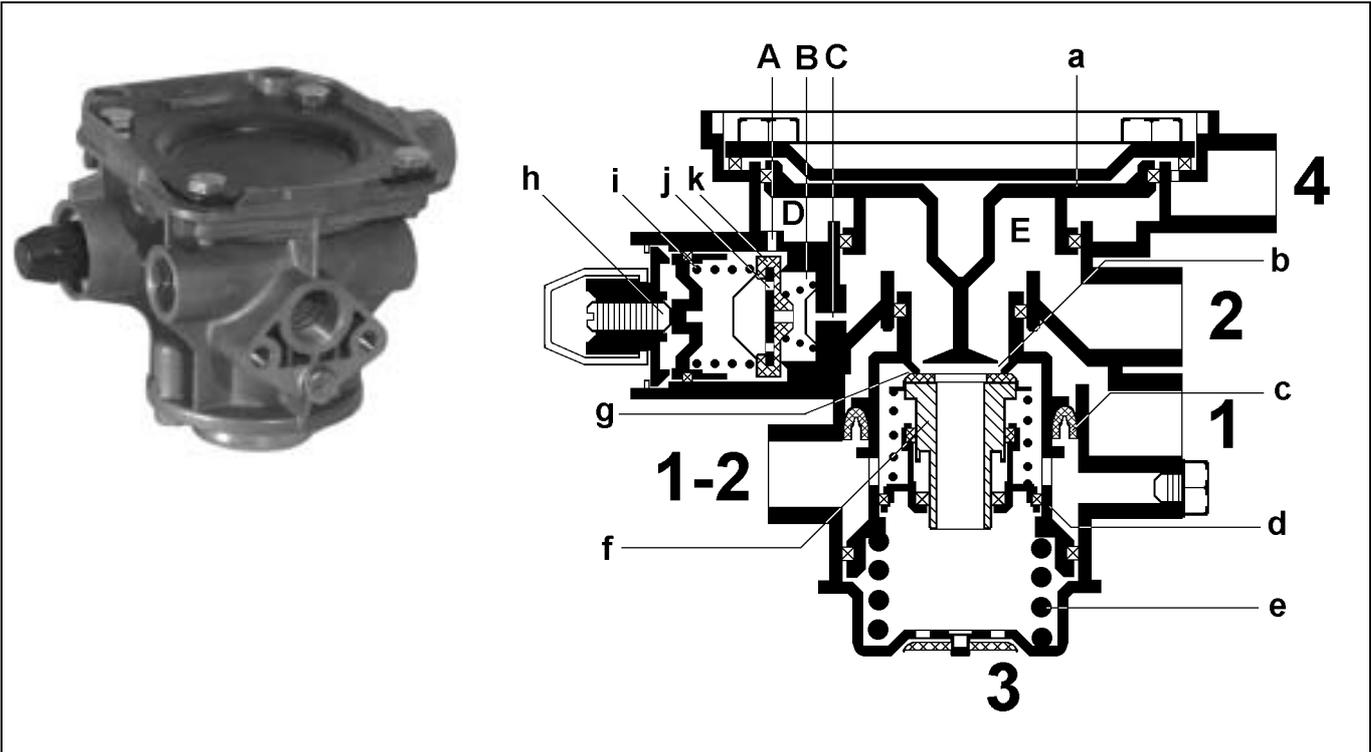
A maximum predominance of 1 bar can be established between ports 2 and 4 by means of adjusting the tension of pressure spring (h) using set screw (g).

When the tractor brakes are released, port 4 is vented and the pressure in ports (2) forces piston (k) upward to the top of its stroke. Inlet (f) remains closed and outlet (a) is opened. The compressed air at ports 2 is exhausted to atmosphere through valve (e) and exhaust 3. Due to the drop in pressure in chamber (A), the compressed air in chamber (E) flows via bores (j) of valve (i) into chamber (D) and on to exhaust 3.

#### b) Automatic Braking

When the trailer is uncoupled, or in the event of a rupture in the supply line, port 1 is exhausted and the pressure acting on the upper side of piston (c) is reduced. The load in pressure spring (d) and the pressure from the reservoirs at port 1-2 force up piston (c), and valve (e) closes outlet (a). As piston (c) continues to move up, it moves away from valve (e) and inlet (f) opens. Via ports 2, the reservoir pressure flows to the brake chambers at a 1:1 ratio.

In the case of the control line rupturing, automatic braking takes effect as described above since the pressure in the supply line is reduced as soon as the towing vehicle is braked.



### Relay Emergency Valve with adjustable predominance 971 002 300 0

#### Purpose:

To control the twin-line braking system of a trailer.

#### Operation:

The relay emergency valve, passing the grooved ring (c), to Port 1-2 and on to the trailer's air reservoir.

When the motor vehicle's braking system is actuated, air flows through the 'control' hose coupling and Port 4 until it reaches the upper side of piston (a). This moves downwards, and as it rests on the valve (f) it closes the outlet (b) and opens the inlet (g). The compressed air from the trailer's air reservoir (Port 1-2) now flows through Ports 2 to the downstream brake valves and Duct C into Chamber B, where the pressure begins to rise.

As soon as the force in Chamber B is greater, the valve (k) is opened against the force of the pressure spring (i). The air now flows through Duct A into Chamber D, acting on the underside of piston

(a). Through the compounding of the forces acting in Chambers D and E, the pilot pressure acting on the upper side of piston (a) is overcome and that piston moves upwards.

Within the range of partial brake application, the valve (f) following piston (a) closes the inlet (g) and a neutral position has been reached. At full brake application, piston (a) keeps the inlet (g) open for the whole of the braking process.

By adjusting the initial tension of the pressure spring (i) by turning the set screw, a pressure predominance of up to 1 bar can be set for Ports 2 over Port 4.

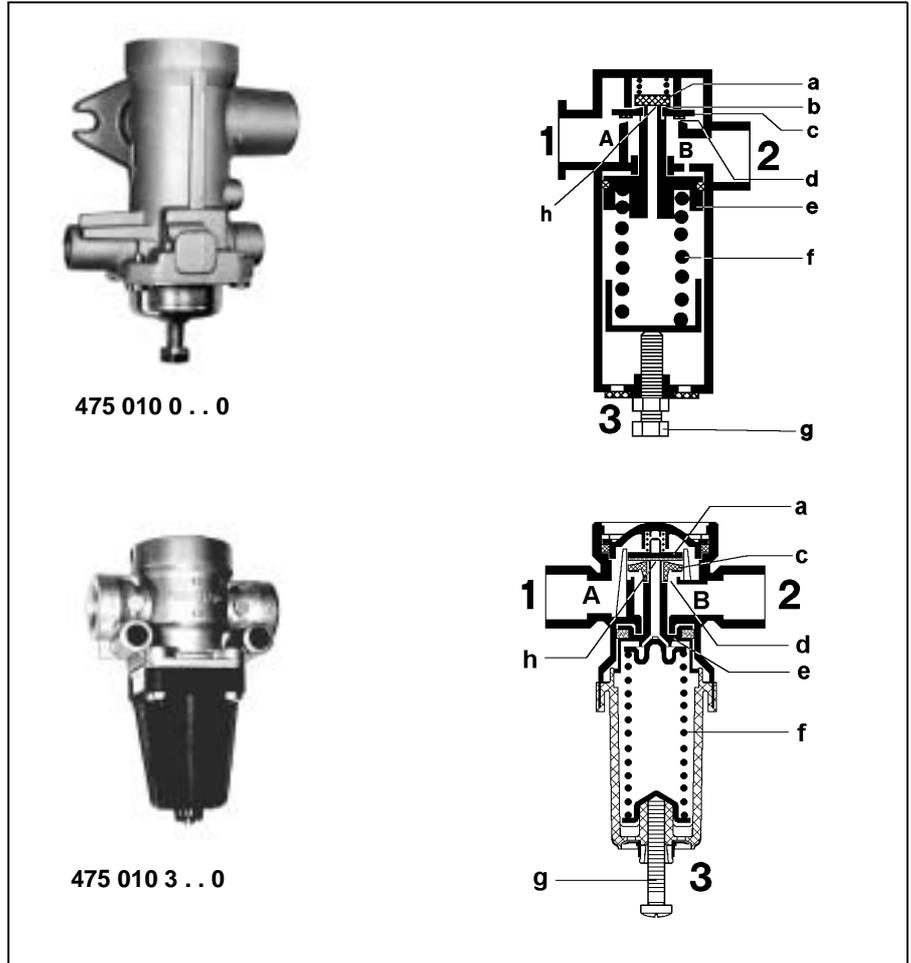
When the braking process in the motor vehicle is ended, causing Port 4 to be evacuated, piston (a) is moved to its upper end position by the air pressure in Ports 2. The compressed air in Ports 2 is evacuated to atmosphere through valve (f) and Vent 3. Due to the fall in pressure in Chamber B, the compressed air in Chamber D flows back through the holes (j) in valve (k) into Chamber B and from there to Vent 3.

When the trailer is disconnected, or if there is a rupture in the supply line, the

pressure in Port 1 is evacuated and the pressure on the upper side of piston (d) is reduced. The force of the pressure spring (e) and the supply pressure at Port 1-2 pushes piston (d) upwards, moving valve (f) and closing the outlet (b). As piston (d) continues to move upwards, it is raised off valve (f) and the inlet (g) opens. The trailer's air supply at Port 1-2 flows through Ports 2 to the downstream brake valves in full.

The relay emergency valve is also available with a release valve 963 001 01. 0, its part number being 971 002 7.. 0. For 'Operation', please refer to Page 68.

## Pressure Limiting Valve 475 010 . . . 0



### Purpose:

To limit output pressure to a preset level.

### Operation:

The air fed into chamber (A) via port 1 (high-pressure) flows through inlet (d) into chamber (B) and on to port 2 (low-pressure). At the same time, piston (e) is pressurized but is initially held at the top of its stroke by pressure spring (f).

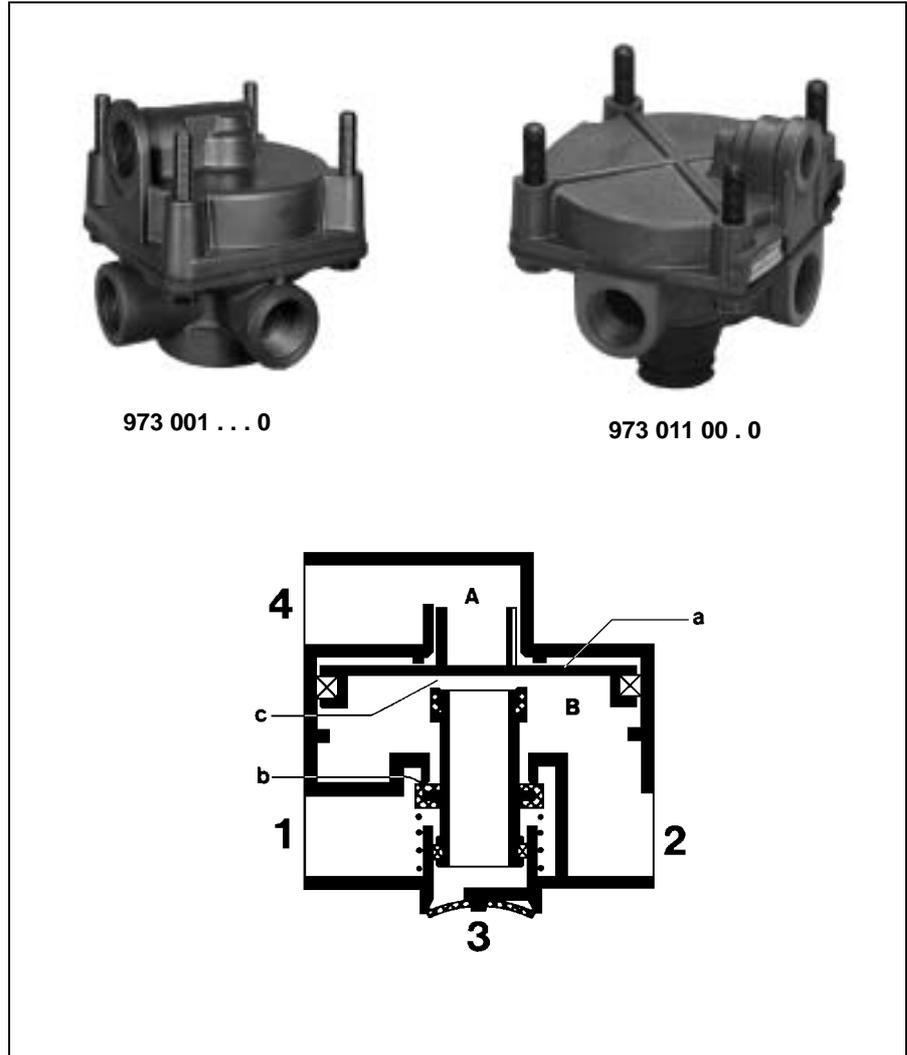
As soon as the pressure in chamber (B) reaches the level set for the outlet pressure, piston (e) overcomes the load in pressure spring (f) and moves down. Valves (a) and (c) close inlets (b) and (d). If the pressure in chamber (B) has increased above the preset level, piston (e) will continue its downward motion, thus opening outlet (h). The excess air will escape to atmosphere through piston (e) and exhaust 3. As the preset pressure level is reached, outlet (h) is closed once more.

In the event of a leakage in the low-pressure line causing a loss in pressure, piston (e) will lift valve (a). Inlet (b) opens and the required quantity of air is fed through. In Variant 475 010 3.. 0, piston (e) will raise valve (c), thus closing inlet (d).

When port 1 is exhausted, the higher pressure in chamber (B) lifts valves (c) and (a). Inlet (d) opens and the low-pressure line is exhausted via chamber (A) and port 1. In the process, piston (e) is returned to the end of its stroke by the load in pressure spring (f).

The set pressure limit can be altered within a certain range by changing the compression of spring (f) by means of adjusting screw (g).

**Relay Valve**  
**973 001 . . . 0 and**  
**973 011 00. 0**

**Purpose:**

To rapidly supply and evacuate compressed air from pneumatic equipment and to reduce response times in pneumatic braking systems.

**Operation:**

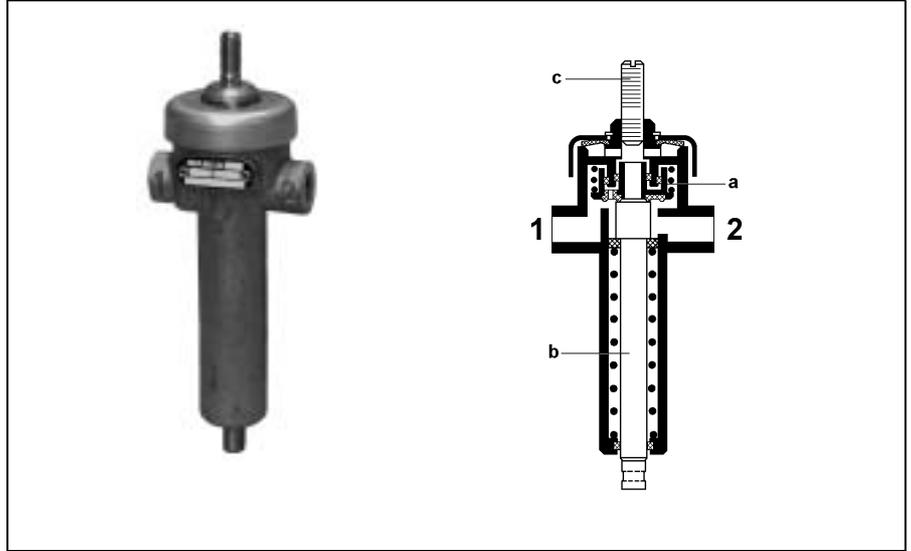
When the braking system is actuated, compressed air flows into chamber (A) via port 4, forcing down piston (a). Outlet (c) is closed and inlet (b) is opened. The supply pressure at port 1 now flows into chamber (B) and to the downstream brake actuators via ports 2.

The pressure building up in chamber (B) acts on the underside of piston (a). As soon as this pressure begins to exceed

the supply pressure in chamber (A), piston (a) is forced up. Inlet (b) closes and a neutral position is reached.

When the pilot pressure is partially reduced, piston (a) is moved up once again. Outlet (c) is opened and the excess pressure at port 2 escapes via exhaust 3. If the pilot pressure at port 4 fails completely, the pressure in chamber (B) forces piston (a) to the top of its stroke and outlet (c) opens. The downstream brake actuators are exhausted fully via exhaust 3.

## Height Limiting Valve 964 001 . . . 0



**Purpose:**

Height limitation on vehicles with an air lift device.

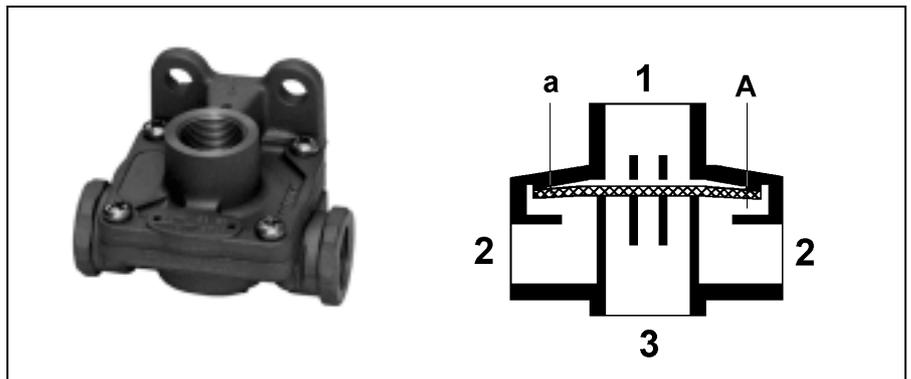
**Operation:**

The height limiting valve is mounted on the chassis of the vehicle using bolt (c). Tappet (b) is connected to the axle via a steel cable. If during a lifting operation using the raise/lower valve, the distance between the chassis and the axle ex-

ceeds the specified limit, tappet (b) is pulled down, followed by valve (a) which closes the connection between ports 1 and 2. When tappet (b) is pulled out, port 2 is exhausted.

After lowering of the chassis, tappet (b) returns to its original position and valve (a) re-opens the connection between ports 1 and 2.

## Quick Release Valve 973 500 . . . 0



**Purpose:**

Rapid evacuation of long control or pilot lines, and of brake actuators.

**Operation:**

When there is no air on the valve, the outer edge of diaphragm (a) which is slightly prestressed seats against exhaust 3, closing the passage from port 1 to chamber (A). Compressed air from port 1 pushes back the outer edge and

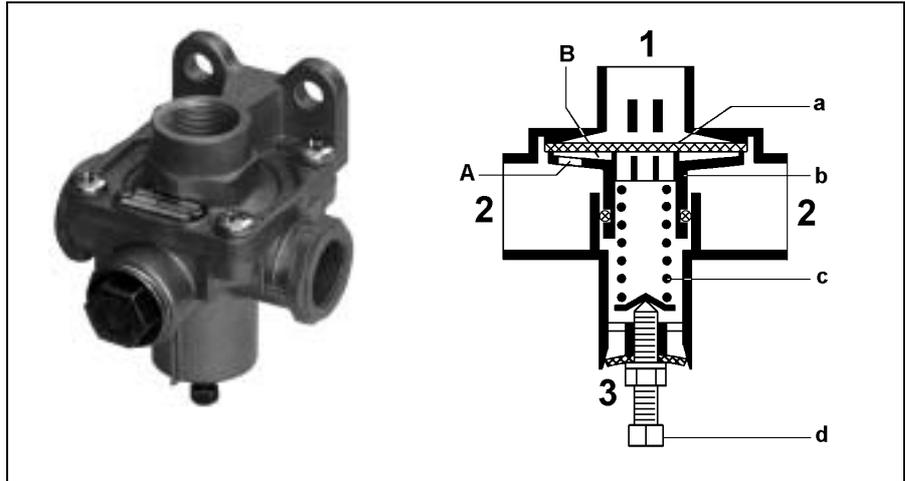
reaches the downstream brake actuators via ports 2.

When the pressure at port 1 is reduced, the higher pressure in chamber (A) forces diaphragm (a) to arch upwards. Depending on the reduction in pressure, the downstream brake actuators are now partially or completely exhausted via exhaust 3.

## 2.

# Adapter Valve and 3/2 Directional Control Valve

### Adapter Valve with linear characteristic 975 001 . . . 0



#### Purpose:

To reduce the braking force of the axle to be adapted during partial brake applications and rapid exhausting of brake actuators. Trailers being operated in mountainous regions and frequently covering downhill journeys always show increased wear on the brake linings of the front wheels because the arrangement of the larger front-wheel brake actuators required for stopping will cause excess braking on the front axle. By using this Adapter Valve, the brake force on the front axle is reduced on the front axle to the extent that both axles are braked evenly; this does not, however, in any way impair the brake force in emergency braking.

#### Operation:

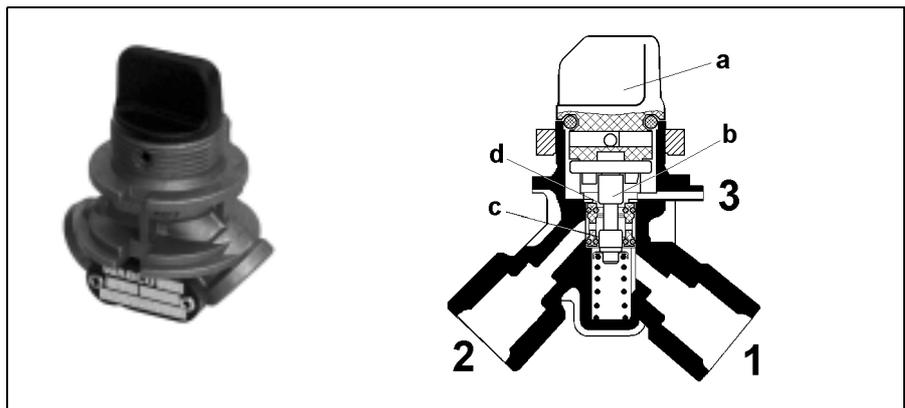
Piston (b) is held at the top of its stroke by the load in pressure spring (c). Diaphragm (a) closes the passage from port 1 to ports 2. When the brakes are applied, the air flows via port 1 to the upper side of diaphragm (a) where pressure begins to build up. As soon as this pressure exceeds that of pressure spring (c) set by means of screw (d), piston (b) is forced down. The air now flows past the outer edge of diaphragm (a) and via ports 2 to the downstream brake actuators.

The pressure building up at ports 2 also acts on the underside of diaphragm (a), thus supporting the force of pressure

spring (c). As soon as these forces exceed the pressure acting on the upper side of diaphragm (a), piston (b) is returned to the top of its stroke. A neutral position is reached.

If the pressure at port 1 is increased further, the load in pressure spring (c) is gradually overcome and the air finally reaches the brake actuators at a 1:1 ratio. After a reduction in pressure at port 1, pressure spring (c) forces piston (b) up to the top of its stroke. The pressure in chamber (B) forces diaphragm (a) to arch upward. Depending on the reduction in pressure at port 1, the brake actuators are exhausted partially or completely.

### 3/2 Directional Control Valve 463 036 . . . 0



#### Purpose:

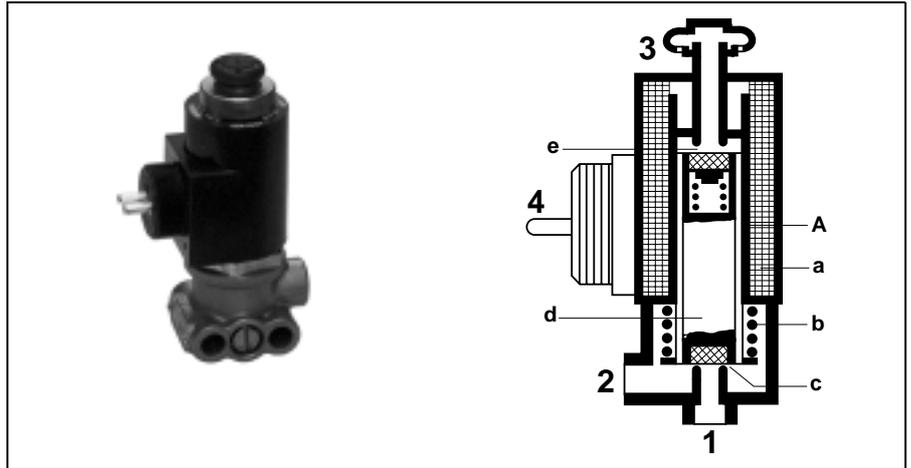
Alternate connection of the service line (consumer) with the pressure line or the exhaust, the valve locking into either position.

#### Operation:

When turning knob (a) is actuated in a rotary direction, piston (b) is moved

downwards via a cam. Outlet (d) closes and inlet (c) opens, and the compressed air at Port 1 flows into the service line via Port 2. When turning knob (a) is turned the other way, piston (b) is returned to its original position by the force of the compression spring. Inlet (c) closes and the service line is exhausted via outlet (b) and Port 3.

## 3/2-Way Solenoid Valve Normally Closed 472 1.. . . . 0



### Purpose:

To pressurize an air line when current is supplied to the solenoid.

### Operation:

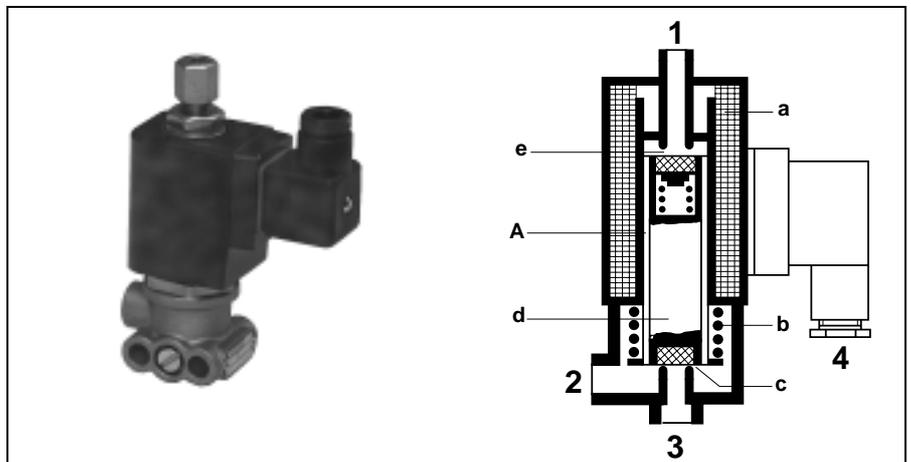
The supply line from the air reservoir is connected to port 1. The armature (d) which forms the valve core keeps inlet (c) closed by the load in pressure spring (b).

When a current reaches solenoid coil (a),

armature (d) is lifted, outlet (e) is closed and inlet (c) is opened. The compressed air from the supply line will now flow from port 1 to port 2, pressurizing the working line.

When the current to solenoid coil (a) is interrupted, pressure spring (b) will return armature (d) to its original position. Inlet (c) is closed, outlet (e) is opened and the working line is exhausted via chamber (A) and exhaust 3.

## 3/2-Way Solenoid Valve Normally Open 472 1.. . . . 0



### Purpose:

To vent an air line when current is supplied to the solenoid.

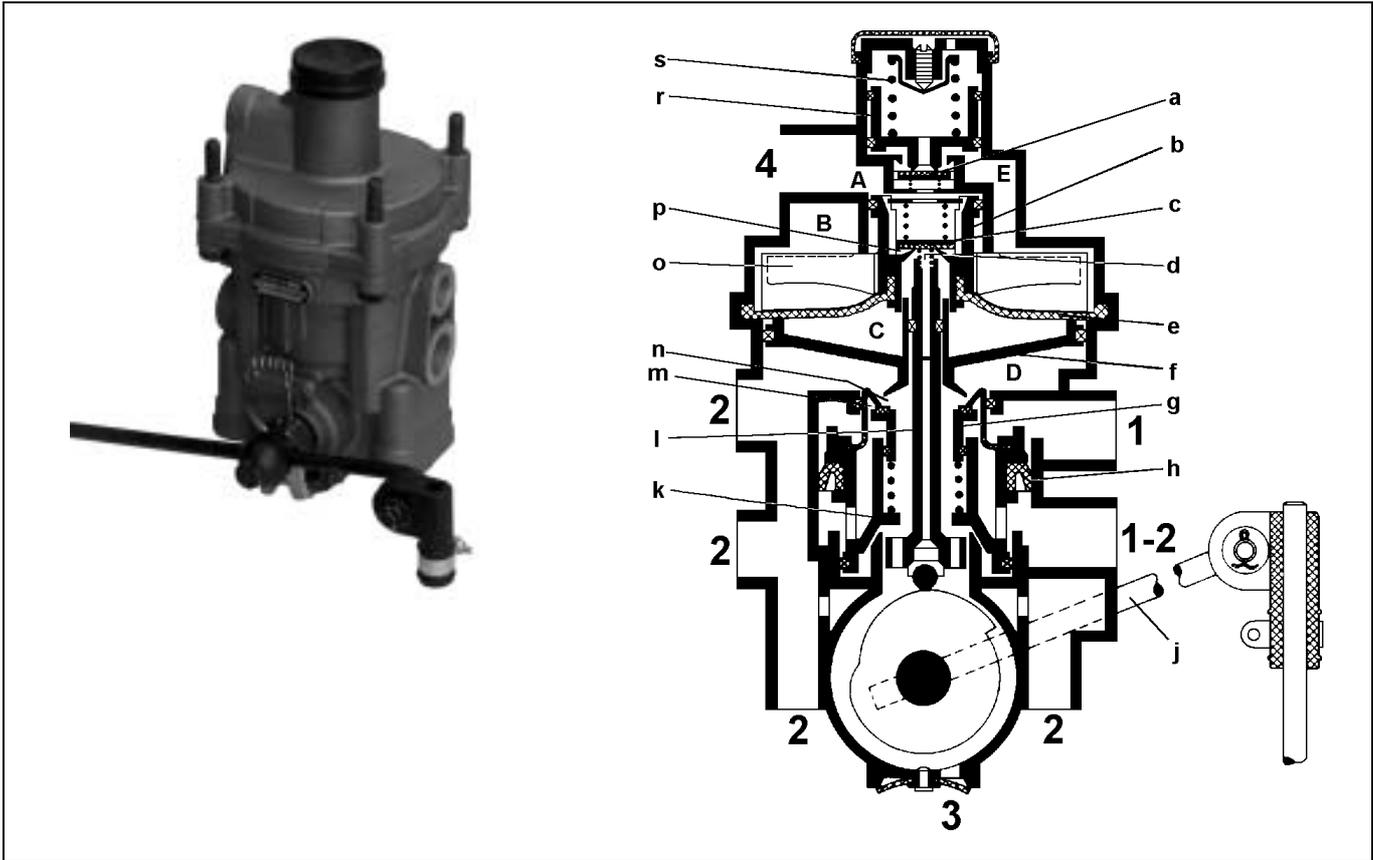
### Operation:

The supply line from the air reservoir is connected to port 1 and thus air is allowed to flow through chamber (A) and port 2 into the working line connected to port 2. The armature (d) which forms the core of the valve is forced down by spring (b), closing outlet (c).

When a current reaches solenoid coil (a),

the armature (d) is lifted, inlet (e) is closed and outlet (c) is opened. The compressed air from the working line will now escape to atmosphere via port 3 and the downstream operating cylinder is exhausted.

When the current to solenoid coil (a) is interrupted, pressure spring (b) will return armature (d) to its original position. Outlet (c) is closed and inlet (e) is opened, again allowing air to pass to the working line via chamber (A) and port 2.



### Load Sensing Relay Emergency Valve 475 712 . . . 0

#### Purpose:

Control of the dual-line trailer braking system when the motor vehicle's braking system is operated. Automatic control of the braking force as a function of vehicle load by means of the integrated load-sensing valve.

Automatically braking the trailer in the event of partial or complete loss of pressure in the supply line.

The Load-Sensing Relay Emergency Valve is specifically designed for semi-trailers with several axles.

#### Operation:

The valve is mounted on the vehicle chassis and is attached to a spring arm on the axle via a linkage. When the vehicle is empty, the distance between the axle and the valve is greatest and lever (j) is in its lowest position. As the vehicle is loaded, this distance is reduced and lever (j) is moved towards its "fully laden" position. The movement of lever (j) causes the cam plate to move tappet (i) to a position corresponding to the vehicle load.

Via the hose coupling of the supply line and port 1, pressure from the motor vehicle passes groove ring (h), port 1-2 and then reaches the semi-trailer's air reservoir. At the same time, piston (k) and valve (g) are moved downwards by the supply pressure. Outlet (n) opens and ports 2 are connected with exhaust 3.

When the motor vehicle's braking system is operated, air flows to chamber (A) via the hose coupling in the control line and port 4, pushing down piston (b) which closes outlet (d) and opens inlet (p). The air from port 4 reaches chamber (C) below diaphragm (e), acting on the effective surface area of relay piston (f).

At the same time, air flows to chamber (B) via open valve (a) and passage (E), acting on the upper side of diaphragm (e). This initial by-pass pressure eliminates any reduction in pilot pressure (up to 1.0 bar max.) in the "partially laden" condition. As the pilot pressure continues to rise, piston (r) is forced up against the load of spring (s), closing valve (a).

Through the pressure building up in chamber (C), relay piston (f) is forced downwards. Outlet (n) closes and inlet (m) opens. The supply pressure at port 1-2 now flows into chamber (D) via inlet (m) and then reaches the downstream brake actuators via ports 2. At the same time, pressure builds up in chamber (D), acting on the underside of relay piston (f). As soon as this pressure exceeds that in chamber (C), relay piston (f) moves upwards, closing inlet (m).

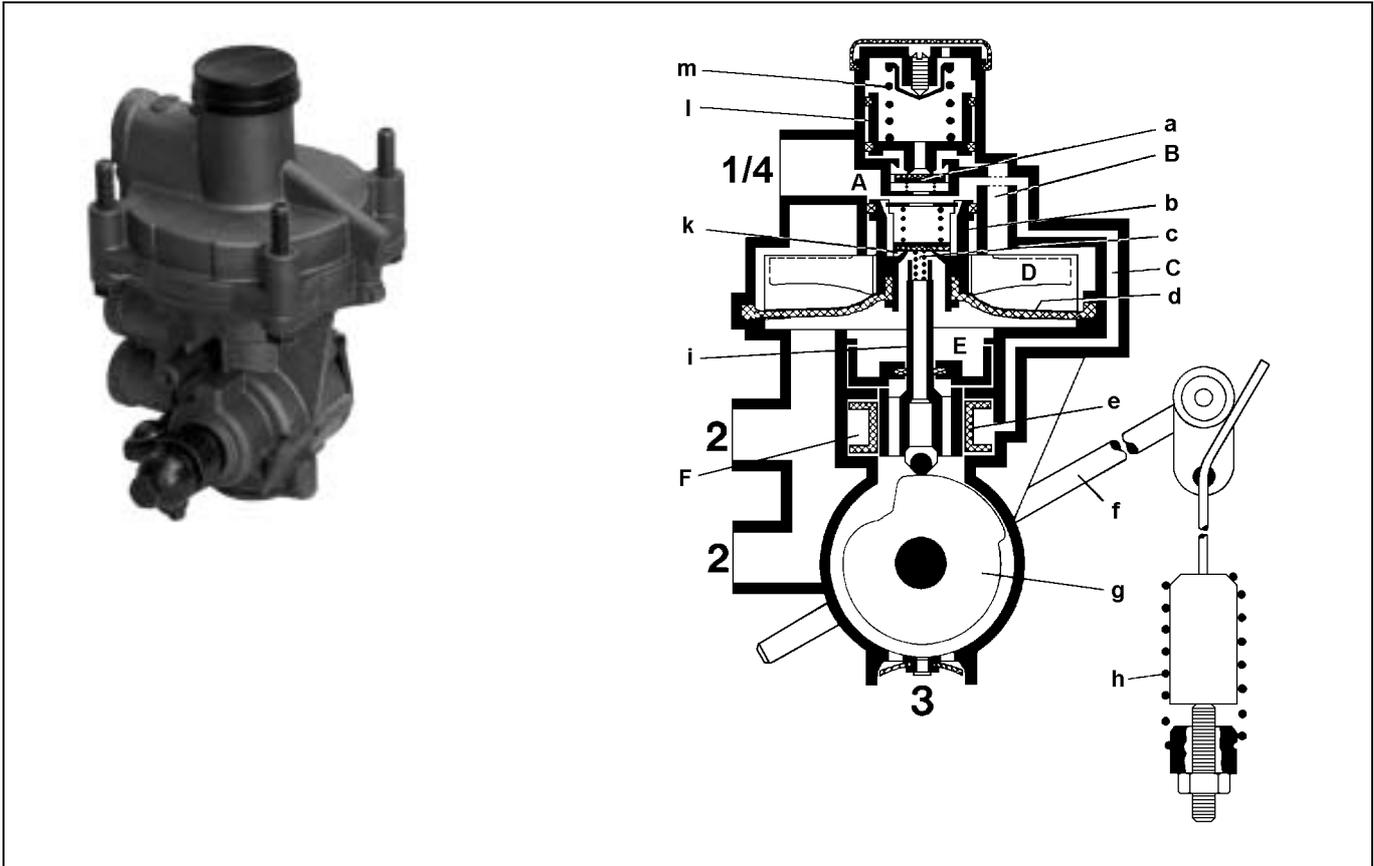
As piston (b) moves downwards, diaphragm (e) is pushed against vane (o), thus continuously increasing the effective diaphragm surface area. As soon as the force acting on the underside of the diaphragm in chamber (C) is equal to that acting on piston (b), the piston moves upwards. Inlet (p) is closed, a balanced position is reached.

The position of tappet (l), which is dependent on the position of lever (j), determines the output braking pressure. Piston (b) with vane (o) needs to cover a stroke according to the position of tappet (l) before valve (c) begins to operate. This stroke also changes the effective surface area of diaphragm (e). In the "fully laden" position, the input pressure at port 4 flows into chamber (C) at a ratio of 1:1. Since relay piston (f) receives full pressure, it keeps inlet (m) open and the input braking pressure is not controlled.

When the motor vehicles braking system is released, port 4 is exhausted and relay piston (f) is pushed into its upper position by the pressure in ports 2. Outlets (d) and (n) open and the air in ports 2 and chamber (C) is released to atmosphere via exhaust 3.

### **Automatic Braking**

When the supply line is disconnected or broken, port 1 will be exhausted and the pressure on the upper side of piston (k) is reduced. The pressure from the air reservoirs at port 1-2 pushes piston (k) upwards. Valve (g) closes outlet (n). As piston (k) continues to move upward, it will leave valve (g) and inlet (m) opens. Full reservoir pressure now reaches the brake actuators via ports 2. In the event of the control line breaking, automatic braking will take place as described above since the pressure in the supply line is reduced in connection with the trailer control valve via the defective line as soon as the towing vehicle is braked.



## Automatic Load Sensing Valve 475 713 . . . 0

### Purpose:

Automatic control of the braking force in pneumatic actuators as a function of the vehicle load.

### Operation:

The load sensing valve is mounted on the vehicle chassis and is actuated via a connecting cable attached to the axle by means of a tension spring. When the vehicle is empty, the distance between the axle and the valve is greatest and lever (f) is in its lowest position. As the vehicle is loaded, this distance is reduced and lever (f) moves from its "empty" position towards its "fully laden" position. The movement of lever (f) causes cam plate (g) to move valve tappet (i) to a position corresponding to the vehicle load.

Output pressure from the relay emergency valve reaches chamber (A) via port 1, acting on piston (b) which is forced down, closing outlet (c) and opening inlet (k). The air now flows to chamber (E) below diaphragm (d) and via ports 2 to the downstream brake actuators.

At the same time, air flows into chamber (d) via opened valve (a) and channel (B), and acts on the upper side of diaphragm (d). This pressure control provides unmodulated output at low pilot pressures. If the pilot pressure increases further, piston (l) is forced up against the load in pressure spring (m) and valve (a) closes.

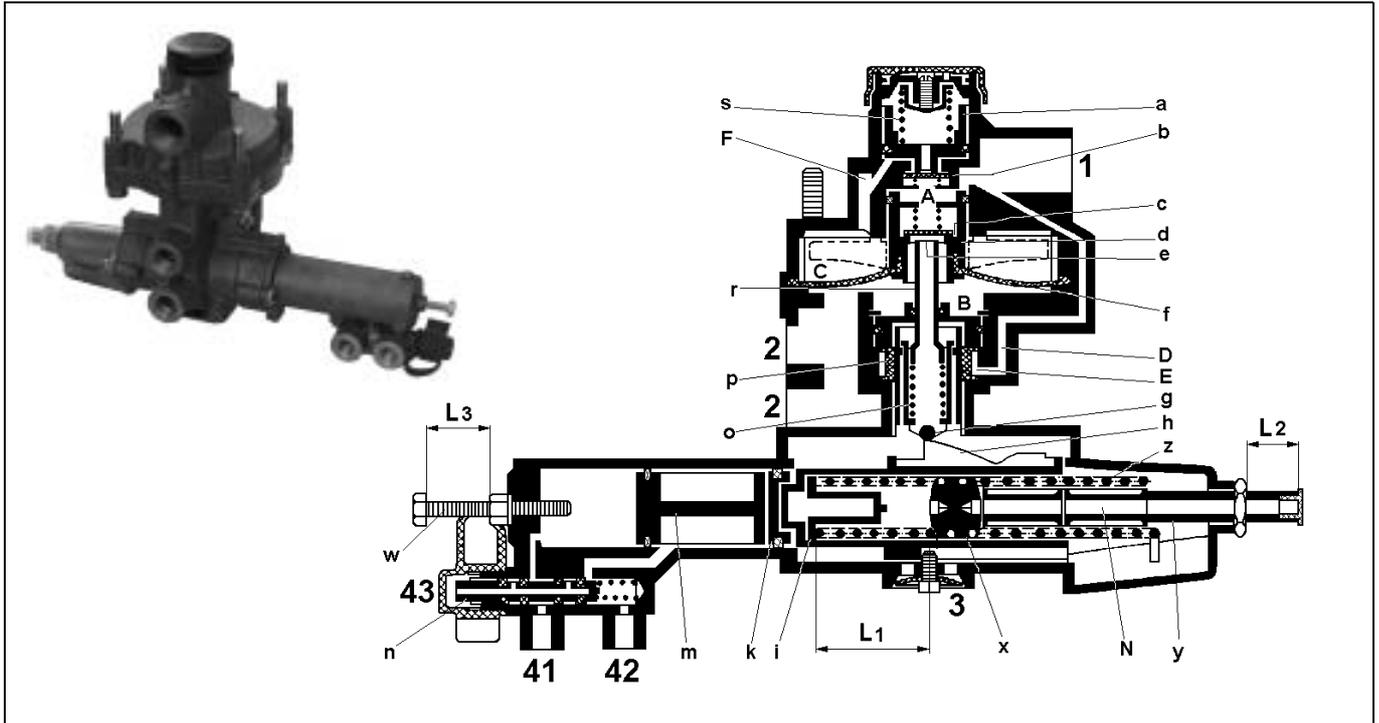
The downward motion of piston (b) releases diaphragm (d) from its seat in the load sensing valve, pushing it against the fanned out portion of piston (b). The effective surface area of the diaphragm is thus increased continuously until it exceeds the area of the upper side of the piston. Thus, piston (b) is raised again and inlet (k) closed. A neutral position is reached. (Inlet (k) will remain open only in fully laden condition "1:1"). The pressure delivered to the actuators of the fully laden vehicle corresponds to the pressure in the load sensing valve delivered from the relay emergency valve. With a partially laden or unladen vehicle, however, this pressure is reduced accordingly.

When the brake pressure has been reduced, piston (b) is forced up by the

pressure in chamber (E). Outlet (c) opens, and the air is exhausted to atmosphere via valve tappet (i) and exhaust 3.

With each brake application, air flows into chamber (F) via passage (C), acting on washer (e) which is pushed against valve tappet (i). At a brake pressure 0.8 bar, a frictional connection is established between valve tappet (i) and the housing. The load sensing valve's reducing ratio is thus locked and remains so even when the distance between the axle and the chassis is changed further. Tension spring (h) compensates these variations in travel.

An integral pressure spring in the load sensing valve moves valve tappet (i) into the "fully laden" position in the event of the linkage fracturing.



## Automatic Load Sensing Valve 475 714 . . . 0

### Purpose:

Automatic regulation of the brake pressure in pneumatic brake actuators on air-sprung axles (axle assemblies) as a function of the pilot pressure of the air bellows.

### Operation:

The load sensing valve is mounted on the vehicle chassis with the exhaust 3 pointing downwards. Ports 41 and 42 are connected to the air suspension bellows on both sides of the vehicle by means of pipes.

The pilot pressure from the bellows acts on pistons (m) and (k). Depending on this pressure which varies with the vehicle load, guide sleeve (i) with its attached cam (h) are moved against spring (z) and the position is set depending on the vehicle load.

When the brakes are applied, compressed air from the relay emergency valve flows into chamber (A) via port 1, pressurizing piston (d) which is forced down, closing outlet (e) and opening inlet (c). The air now flows into chamber (B) below diaphragm (f) and to the downstream actuators via ports 2.

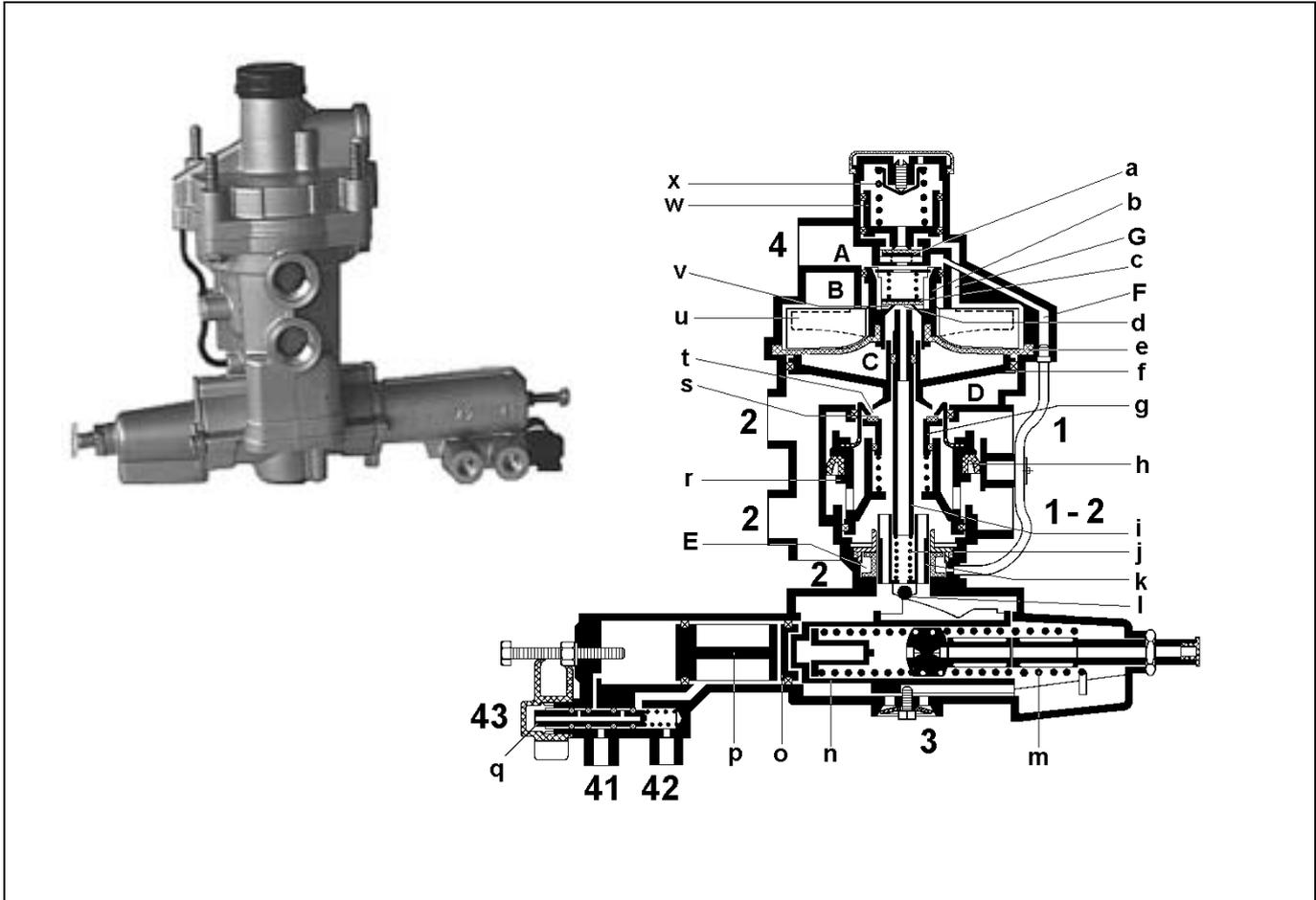
At the same time, air flows into chamber (C) via opened valve (b) and passage (F), acting on the upper side of diaphragm (f). This pressure control provides unmodulated output at low pilot pressures when the vehicle is partially laden. If the pilot pressure increases further, piston (a) is forced up against the load in pressure spring (s) and valve (b) closes.

The downward motion of piston (d) releases diaphragm (f) from its seat in the load sensing valve, pushing it against the fanned-out portion of piston (d). The effective surface area of the underside of diaphragm is thus increased continuously until the forces on either side of the piston are the same as on the underside of diaphragm (f). Thus, piston (d) is raised again and inlet (c) closed. A neutral position is reached. (Inlet (c) will remain open only in the fully laden condition). The pressure in the actuators then corresponds to the vehicle load and the output brake pressure of the tractor brake valve or the relay emergency valve.

When the brake pressure is reduced (release of the brakes), piston (d) is forced up by the pressure in chamber (B). Outlet (e) opens and the air is exhausted to atmosphere via valve tappet (r) and exhaust 3.

Every brake application forces air into chamber (E) via passage (D), acting on moulded rubber part (p) which is forced against valve tappet (r). Any brake pressure > 0.8 bar establishes a frictional connection between valve tappet (r) and the housing. The load sensing valve's reduction ratio is blocked and is maintained even when dynamic axle load shifting occurs when the brakes are applied. If the bellows load increases with a partially laden vehicle, roller (g) is pushed against spring (o). Tappet (r) does not move from the position it was in when the brakes were first applied.

For checking the load sensing valve, a test hose is connected to port 43. As it is screwed into place, piston (n) is pushed into the housing, breaking the connection of ports 41 and 42 to pistons (m) and (k). At the same time, a connection is established from port 43 to pistons (m) and (k). The load sensing valve adjusts to a regulating position corresponding to the pressure in the test hose.



## Load Sensing Relay Emergency Valve 475 715 . . . 0

### Purpose:

Regulation of the dual-line trailer braking system when the towing vehicle's braking system is actuated.

Automatic regulation of the brake force by means of the integrated load-sensing valve as a function of the vehicle load and thus of the actuating pressure of the air bellows.

Automatic braking of the trailer in the event of partial or complete loss of pressure in the supply line.

The Load-Sensing Relay Emergency Valve is specifically designed for air-sprung semi-trailers with several axles.

### Operation:

The valve is mounted on the vehicle chassis with the exhaust 3 pointing downwards. Ports 41 and 42 are connected to the air suspension bellows on both sides of the vehicle.

The pilot pressure from the air suspension bellows acts on pistons (p) and (o). Depending on this pressure which varies with the vehicle load, guide sleeve (n) with its attached cam is moved against spring (m) and the position is set depending on the vehicle load.

The air from the motor vehicle reaches the semi-trailer's air reservoir via the "supply" hose coupling, port 1, port 1-2 and grooved ring (h). At the same time, the supply pressure forces down piston (r) and thus valve (g). Outlet (t) opens and ports 2 are connected with exhaust 3.

When the brakes are applied, compressed air flows via the hose coupling in the control line and port 4 to chamber (A), acting on piston (b) which is forced downwards, closing outlet (d) and opening inlet (v). The compressed air from port 4 reaches chamber (C) below diaphragm (e), acting on the effective surface area of relay piston (f).

At the same time, air flows into chamber (B) via open valve (a) and passage (G), acting on the upper side of diaphragm (e). This pressure control provides unmodulated output at low pilot pressures (up to 1.0 bar) when the vehicle is partially laden. As the pilot pressure increases further, piston (w) is forced up against the load in pressure spring (x) and valve (a) closes.

The pressure building up in chamber (C) forces relay piston (f) downwards. Outlet (t) closes and inlet (s) opens. The supply pressure present at port 1-2 now flows into chamber (d) and to the downstream brake actuators via ports 2.

This causes pressure to increase in chamber (D) which acts on the underside of relay piston (f). As soon as this pressure exceeds that in chamber (C), relay piston (f) moves upwards and inlet (s) closes.

As piston (b) moves downwards, diaphragm (e) moves against vane (u), thus

continuously increasing the effective surface area of the diaphragm. As soon as the force acting on the underside of the diaphragm in chamber (C) is the same as that acting on piston (b), the piston is moved upwards. Inlet (v) is closed and a neutral position is reached.

The position of tappet (i) which depends on the position on guide sleeve (n), determines the output pressure. Piston (b) with vane (u) must cover a stroke corresponding to the position of tappet (i) before valve (c) begins to operate. This stroke changes the effective surface area of diaphragm (e). In the "fully laden" position, the input pressure at port 4 flows into chamber (C) at a ratio of 1:1. Since relay piston (f) receives full pressure, it keeps inlet (s) open and the input braking pressure is not controlled.

When the motor vehicle's braking system is released, port 4 is exhausted and relay piston (f) is pushed into its upper position by the pressure in ports 2. Outlets (d) and (t) open and the air in ports 2 and chamber (C) is released to atmosphere via exhaust 3.

Every brake application forces air into chamber (E) via passage (F), acting on moulded rubber part (k) which is forced against valve tappet (i). Any brake pressure > 0.8 bar establishes a frictional connection between valve tappet (i) and the housing. The relay emergency valve's reduction ratio is blocked and is maintained even when dynamic axle load shifting occurs when the brakes are applied. If the bellows load increases with a partially laden vehicle, roller (l) is pushed against spring (j). Tappet (i) does not move from the position it was in when the brakes were first applied.

For checking the load-sensing valve, a test hose is connected to port 43. As it is screwed into place, piston (q) is pushed into the housing, breaking the connection of ports 41 and 42 to pistons (p) and (o). At the same time, a connection is established from port 43 to the pistons. The load-sensing valve adjusts to a regulating position corresponding to the pressure in the test hose.

### **Automatic Braking:**

When the supply line is disconnected or broken, port 1 will be exhausted and the pressure on the upper side of piston (r) is reduced. The pressure from the air reservoirs at port 1-2 pushes piston (r) upwards. Valve (g) closes outlet (t). As piston (r) continues to move upward, it will leave valve (g) and inlet (s) opens. Full reservoir pressure now reaches the brake actuators via ports 2.



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# Anti-Lock Braking System (ABS)

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**Introduction:**

Anti-Lock Braking Systems (ABS) are used to prevent locking of a vehicle's wheels as a result of excessive actuation of the service braking system, especially on slippery roads. As a consequence, lateral control is maintained on braked wheels even at full brake application to ensure that both the stability and steerability of a vehicle are ensured as far as physically possible. At the same time, the utilization of the available adhesion of the tyre on the road and thus vehicle retardation and stopping distance are optimized.

Following their introduction by WABCO Fahrzeugbremsen, a division of WABCO Standard GmbH, in the early Eighties, Anti-Lock Braking Systems (ABS) are now being offered by nearly all European manufacturers of commercial vehicles.

In recent years, WABCO has continuously worked on further improving the excellent quality and performance characteristics of ABS.

Key developments have been:

- The introduction of Drive-Slip Control systems (ASR) in 1986
- The introduction of the ABS "VARIO-C" for trailers in 1989

The increasing demand of trailer manufacturer for simple installation and testing whilst maintaining the usual WABCO quality standard has been the reason for WABCO developing its new ABS generation, **Vario Compact ABS - VCS**. Both modular systems are based on state-of-the-art electronics technology with high-performance micro computers and high-capacity data storage, taking modern diagnostic principles into account.

- With the ABS/ASR 'C' generation for motor vehicles and motor coaches, WABCO has presented a system which offers the following essential technical novelties:

**ABS-Functions**

- Control Performance**  
By further optimizing the control algorithm, the utilization of adhesion and control comfort were improved even more.
- Setting ECU Parameters**  
Modern memory modules can be used to set customer-specific vehicle data either when the ECU is being made or after production of a commercial vehicle.

**ASR-Functions**

- Pneumatic Engine Control**  
In combination with a proportional valve designed for that purpose and a suitable control cylinder in the actuating linkage of the fuel-injection pump, considerable improvements in traction and in control comfort are achieved.
- Electronic Engine Control**  
The ECU has interfaces to commercial electrical or electronic engine control systems, and corresponding SAE interfaces.
- Functional Display**  
The driver is informed of any automatic actuation of the ASR system, thus indicating to him that the road may be slippery.

**Special Functions**

- Top Speed Control
- ABS/ASR Function Switch
- Diagnostic Interface / Flash Code

WABCO has continuously improved the performance of this safety system. The constantly rising competitive pressure in the transport trade and falling vehicle prices have not stopped at ABS, either.

The highlights listed below which apply to the 4<sup>th</sup> generation of ABS/ASR are intended to specifically meet these requirements.



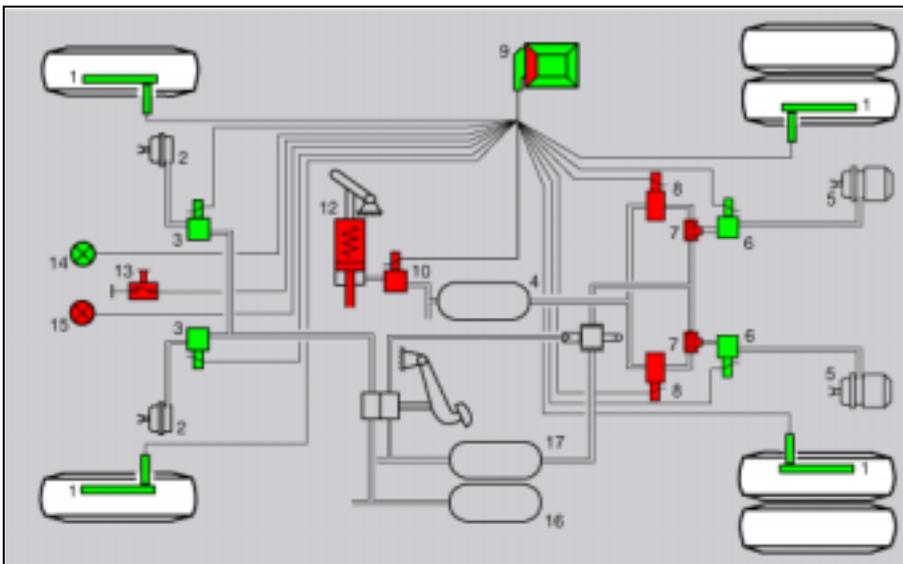
### ABS/ASR D Version The New Generation of Control Units

Changed vehicle concepts, the desire for further improving functions and continuous cost reductions for the system have culminated in the development of the D Version of ABS/ASR.

#### Special Features:

- The single plug concept:  
This design permits the allocation of partial cable harnesses on the vehicle to their respective plugs.
- The valve relays previously located outside the control unit have now been integrated.

- The D Version has a databus interface for communication with other systems.
- ABS/ASR systems now only require one ASR solenoid valve (differential brake valve).

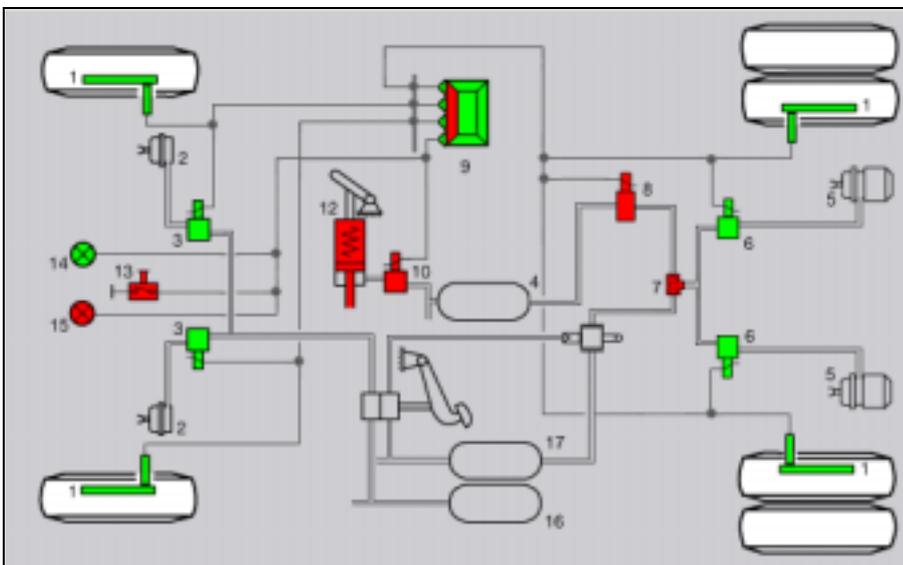


### 4-Channel ABS/ASR (C Version)

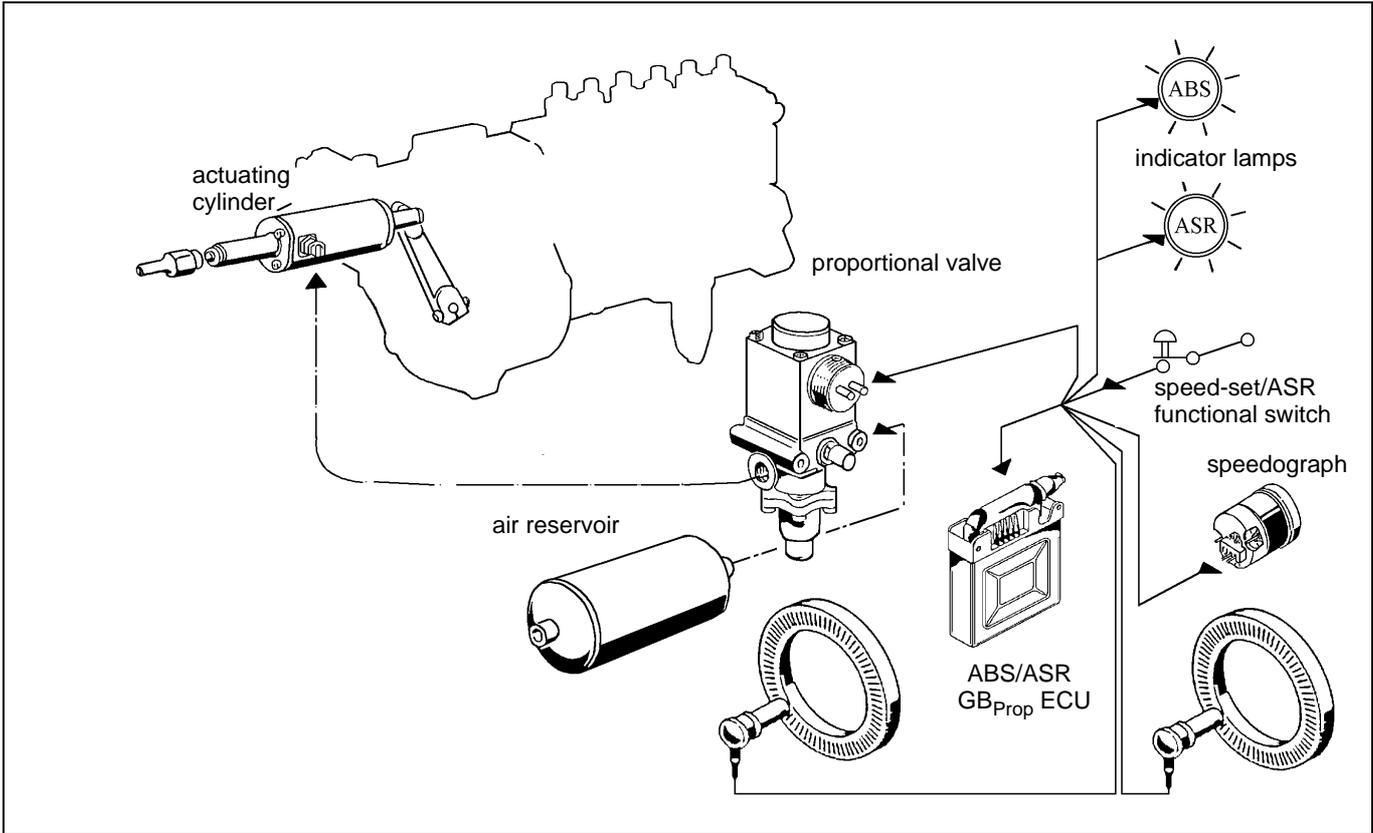
4-wheel motor lorry with rear-wheel drive

- ABS/ASR components
- ABS components

1. pole wheel and sensor
2. brake chamber (front axle)
3. ABS solenoid control valve
4. air reservoir
5. Tristop spring-brake actuator (rear axle)
6. ABS solenoid control valve
7. two-way valve
8. differential brake valve
9. electronic control unit
10. proportional valve
12. ASR actuating cylinder
13. ASR functional switch
14. ABS indicator lamp
15. ASR indicator lamp



### 4- Channel ABS/ASR (D Version)



### Integrated Speed Limiter GB<sub>Prop</sub>

WABCO's top speed limiting system with its proportional valve (GB<sub>Prop</sub>) complies with the latest European legislation for the equipment of heavy-duty commercial vehicles with cruise control systems and has been granted EC type approval for the parts.

Its components include the ABS/ASR ECU, a proportional valve and actuating cylinders which have been used successfully in recent years in WABCO-ABS/ASR systems for pneumatic engine control. Other components include idle-stop cylinders (only required for single lever fuel-injection pumps), a speed set/ASR functional switch and an ASR indicator lamp plus a speedograph with C3/B7 output.

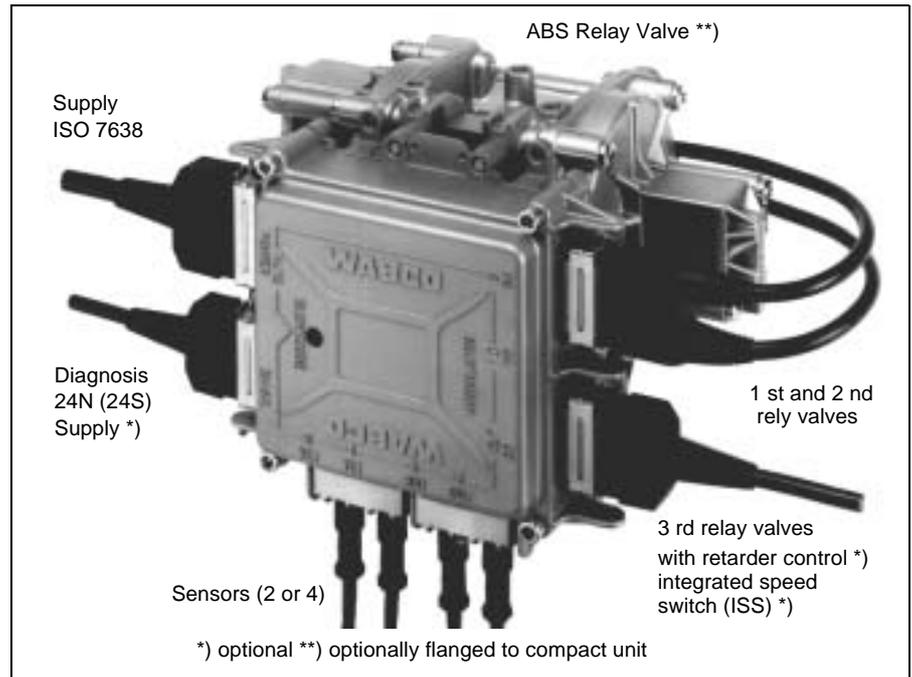
The speed limiter begins to operate even before the vehicle has reached the maximum speed stored in the ECU in a non-volatile EE-PROM memory. Via the proportional valve and the actuating cylinder, the control lever of the fuel-injection pump is moved so that the vehicle's permissible maximum speed cannot be exceeded.

In addition, GB<sub>Prop</sub> allows the driver to set a limiting speed freely selectable anywhere between 50 k.p.h. and the preset maximum speed by actuating the speed-set/ASR functional switch and have this speed monitored by the system although he has to continue to push down the accelerator pedal (this not being a fully automatic cruise control system).

The top speed stored in the Electronic Control Unit (ECU) can either be defined by the vehicle manufacturer (at the end of production) or by officially authorized workshop personnel at a service station using WABCO's Diagnostic Controller.

The ECU stores any faults which may occur by type and frequency and, via the interface designed to ISO 9141 and by means of the Diagnostic Controller, permits the error memory to be read out or deleted, functional testing to be done and the system's parameters to be set.

## Vario Compact ABS (VCS) for Trailers



VCS is a ready-to-install ABS system for trailers meeting all legal requirements of the A category.

The range of systems extends from a 2S/2M system for semitrailers to a 4S/3M system for towbar trailers or, for instance, a semitrailer with a steering axle.

In keeping with the specific needs of the trailer manufacturers, VCS is available either as a compact unit or as a modular system, i. e. ECU and valves are installed separately.

Both ABS relay valves and ABS solenoid valves can be used. The choice depends on the braking system used, and more particularly on time response. It is important that the appropriate ECU is used.

If the control valves are not electrically actuated, the ordinary increase or decrease of brake pressure the driver needs is not affected. The special function of "maintaining brake pressure" serves to improve both the control performance of the ABS system, and air consumption.

one ECU (Electronic Control Unit) with one, two or three control channels, subdivided into the following functional groups:

- input circuit
- main circuit
- safety circuit
- valve actuation

In the input circuit, the signals generated by the respective inductive sensors are filtered and converted into digital information for determining period lengths.

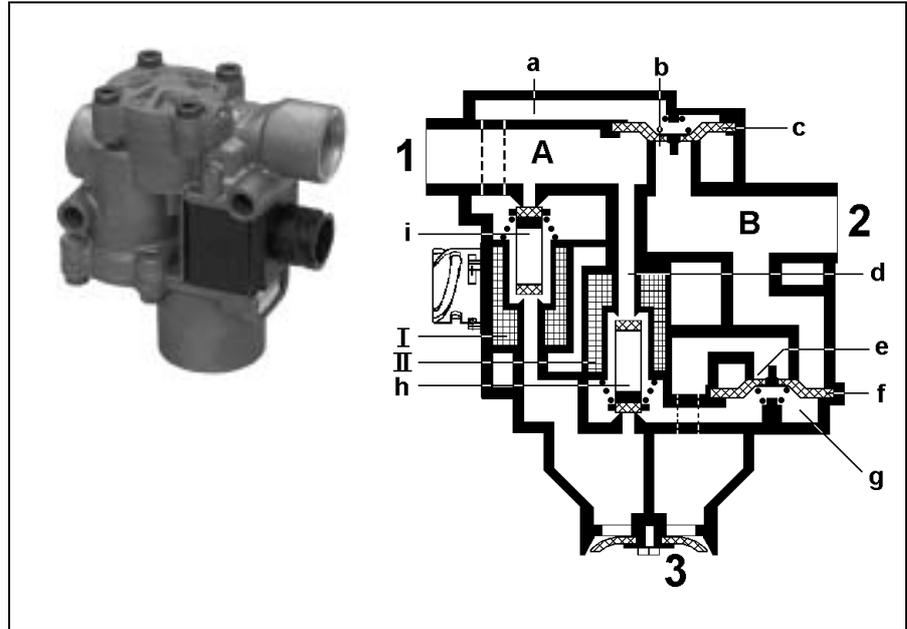
The main circuit consists of a microcomputer. It contains a complex programme for the computation and logical operation of the control signals and for outputting the actuating variables for the valve control system.

The safety circuit monitors the ABS system, i. e. the sensors, solenoid control valves, ECU and wiring, before the vehicle moves off and whilst it is in motion, irrespective of whether the brakes are being actuated or not. It alerts the driver to any errors or defects by means of an indicator lamp and shuts off the whole or part of the system. Whilst the conventional brake remains operational, it is only the anti-lock system which is deactivated wholly or in part.

The valve actuation contains (output stages) which are actuated by the signals from the main circuit and which switch the current for actuating the control valves.

The electronic control unit of the VARIO Compact ABS is a further development from the established Vario-C ABS, building on its proven principles.

### Solenoid Control Valve 472 195 . . . 0



#### Purpose:

The purpose of the solenoid control valve on the trailer is to **increase, reduce or hold** the pressure in the brake cylinders during a braking process depending on the control signals, in milliseconds, received from the ECU.

#### Operation:

##### **a) Pressure Increase**

Valve solenoids I and II are not energized, the inlet of valve (i) and the outlet of valve (h) are closed. The pilot chamber (a) of diaphragm (c) is pressureless. The compressed air at Port 1 flows from Chamber A through the open inlet (b) into Chamber B and from there through Port 22 to the brake cylinders. At the same time, the compressed air also flows through the hole (d) into the pilot chamber (g) of diaphragm (f), and outlet (e) remains closed.

##### **b) Pressure Reduce**

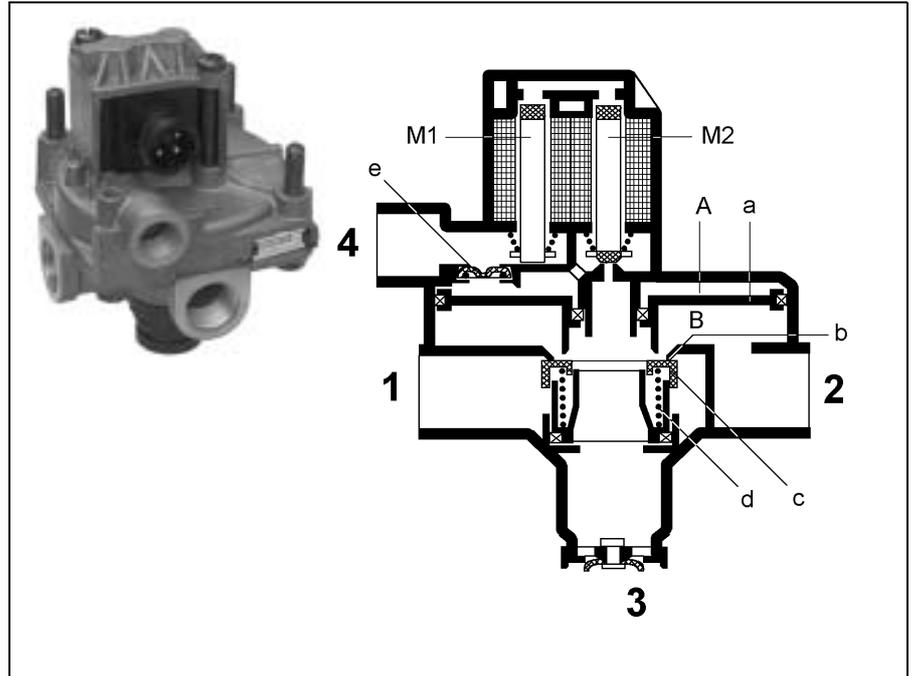
When the ABS ECU transmits the signal to decrease the pressure, valve solenoid I is energized, valve (i) closes the passage to Vent 3 and the passage to the pi-

lot chamber (a) is opened. The compressed air from Chamber A flows into the pilot chamber (a) and diaphragm (c) closes inlet (b) leading into Chamber B. At the same time, valve solenoid II reverses, valve (h) closes the passage of hole (d), permitting the compressed air from pilot chamber (g) to escape through Vent 3. Diaphragm (f) opens outlet (e) and the air at Port 2 escapes to atmosphere via Vent 3.

##### **c) Pressure Hold**

By receiving a pulse, the passage to Vent 3 is closed by valve (h) as valve solenoid II reverses. The compressed air from Chamber A flows through the hole (d) back into the pilot chamber (g) and diaphragm (f) closes outlet (e). Thus the pressure in Chamber B and thus the brake cylinders cannot increase or decrease.

## ABS Relay Valve 472 195 02 . 0



### Purpose:

The purpose of the solenoid control valve on the trailer is to **increase, reduce or hold** the pressure in the brake cylinders during a braking process depending on the control signals, in milliseconds, received from the ECU. This consists of two subassemblies:

The actual relay valve and the electromagnetic control valve.

### Operation:

#### a) Supply pressure present but no:

The annular piston (c) is pushed against the seat (b) by the pressure spring (d), closing Port 1 against Chamber B (and thus Port 2).

As (e. g. 1 bar) is applied at Port 4, this flows via the solenoids (M1 and M2) into the upper piston chamber A, forcing piston (a) downwards. A small gap opens at the seat (b) and air from Port 1 flows into Chamber B. At Outlet 2 and thus in the brake cylinders, pressure begins to rise. Since the upper and lower sides of piston (a) have identical surfaces, that piston will return to its original position as soon as the pressure at 2 is equal to that at 4. The annular piston (c) is again in contact with the seat (b) and the passage from 1 to Chamber B is closed.

When the falls, piston (a) is raised and the pressure in Port 2 escapes to Vent 3 through Chamber B.

#### b) Operation in ABS control:

##### Pressure Increase:

The solenoids (M1 and M2) are dead and there is actuating pressure in Chamber A. Piston (a) is in its lower end position and the air supply flows from Port 1 to 2.

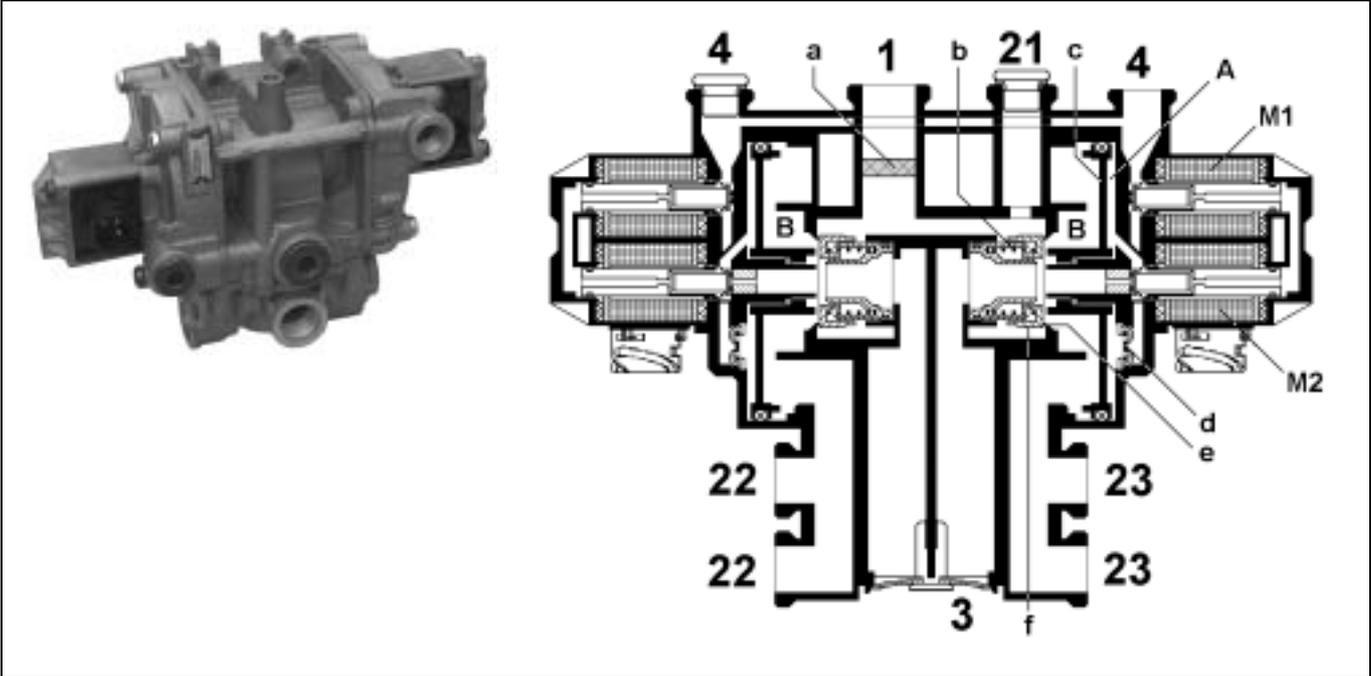
##### Pressure hold:

Solenoid M1 is energized and the armature has attracted. This causes the air supply from Port 4 to Chamber A to be interrupted (in spite of the rise in actuating pressure).

The pressures in Chamber A and B are equalized. The annular piston again rests on seats (b). The compressed air cannot flow from 1 to 2 or from 2 to 3 (outside).

##### Pressure Reduce:

Solenoid M2 is energized, the passage to Chamber A thus being closed. The raised seal at the foot of M2 opens the passage to Vent 3 and the pressure from Chamber A escapes to atmosphere through the inside opening of the annular piston (a). This causes piston (a) to be raised and the pressure from Port 2 and the connected brake cylinder escapes to atmosphere through Chamber B and Vent 3.



### ABS Relay Valve 472 195 04 . 0 (Flat twin valve)

#### Purpose:

ABS relay valve (flat twin valve) consists of two relay valve parts with common ports for supply pressure and control pressure.

It is used in the air braking system in front of the brake cylinders to modulate the braking pressure in the brake cylinders. When the valve is activated by the ABS electronic control unit, the pressure in the brake cylinders is modulated (pressure increase, pressure hold, pressure release) regardless of the pressure allowed to pass by the brake valve or the emergency valve. The device has a two-relay-valve function in passive position (i.e. without solenoid activation), and is used to increase and decrease pressure in the brake cylinder through short response and pressure build-up and release times.

#### Operation:

##### Pressure build-up without ABS Control:

Both valve solenoids (M1 and M2) are de-energized, the annular piston (f) is pressed against the seat (e) by the pressure spring (b), and the passage from port 1 to chamber B is closed.

If control pressure is supplied at port 4, it

flows through the solenoids (M1 and M2) into the upper piston chamber A, presses the piston (c) against the annular piston (f) and opens the narrow gap in the seat (e). The supply pressure at port 1 flows through the filter (a) into chamber B and into port 23. There is pressure build-up also in the brake cylinders. The same process also takes place in the opposite relay valve for ports 22. Since the upper and lower sides of the piston (c) have equal surfaces, the piston returns to its original position as soon as the pressure at ports 22 and 23 is equal to the pressure at port 4. The annular piston (4) lies close to the seat (e) again, and the passage from port 1 to chamber B is blocked.

If the control pressure decreases, the piston (c) is raised and the pressure in ports 22 and 23 is released via chamber B to exhaust 3.

##### Operation with ABS-Control:

###### a) Pressure build-up

The solenoids (M1 and M2) are de-energized and control pressure builds up in chamber A. The piston (c) is in its left stop position and air supply flows from port 1, through ports 22 and 23, into the brake cylinders.

###### b) Pressure release

Solenoid M2 is energized and closes the passage from port 4 to chamber A. The

raised gasket at the bottom of M2 clears the way to exhaust 3 and the excess pressure from chamber A escapes through the inner opening of the piston (c) to exhaust 3. This raises the piston (c), and the pressure on the brake cylinder is released accordingly.

###### c) Pressure hold

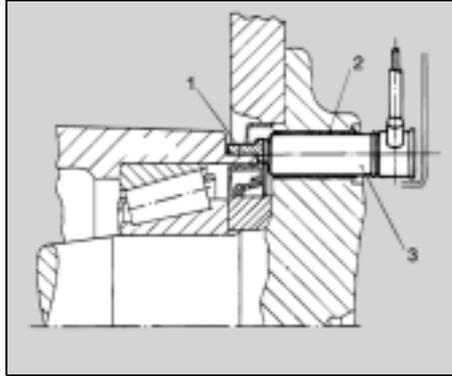
Solenoid M2 is de-energized again, solenoid M1 is energized, and the armature attracted. Thus, (despite the increasing control pressure) air supply from port 4 to chamber 4 is interrupted.

There is equal pressure in chambers A and B, and the annular piston (f) is pressed against the seat (e) by the pressure spring (b). Compressed air can neither flow from 1 to 22 and 23, nor from 22 and 23 to 3 (into the atmosphere).

###### d) Pressure release

Power is supplied to solenoids M1 and M2. The passage from port 4 to chamber A is closed and compressed air from chamber A escapes via the check valve (d) on port 4, whereas the pressure from chamber B and from ports 22 and 23 now escapes through the fully open outlet (the piston (c) is in its right stop position) on the seat (e) and exhaust 3 into the atmosphere.

## ABS Sensor Installation



The rotary motion of the wheel is picked up by means of a pole wheel (1) moving with the hub and a pulse-generating sensor (3) held in the brake spider plate by a clamping bush (2). Pole wheels for medium and heavy-duty commercial vehicles have 100 teeth.

Because of the diagonal reference speed forming, the ratio of the number of teeth and the wheel's circumference must be identical on front and rear wheels, any deviation not exceeding a few percent.

## ABS Sensor 441 032 . . . 0



The inductive sensor comprise a permanent magnet, core and coil. The magnetic flux surrounding the coil is cut by the

rotating motion of the toothed wheel inducing an A.C. voltage whose frequency is directly proportional to wheel speed.

## Clamping Bush 899 759 815 4



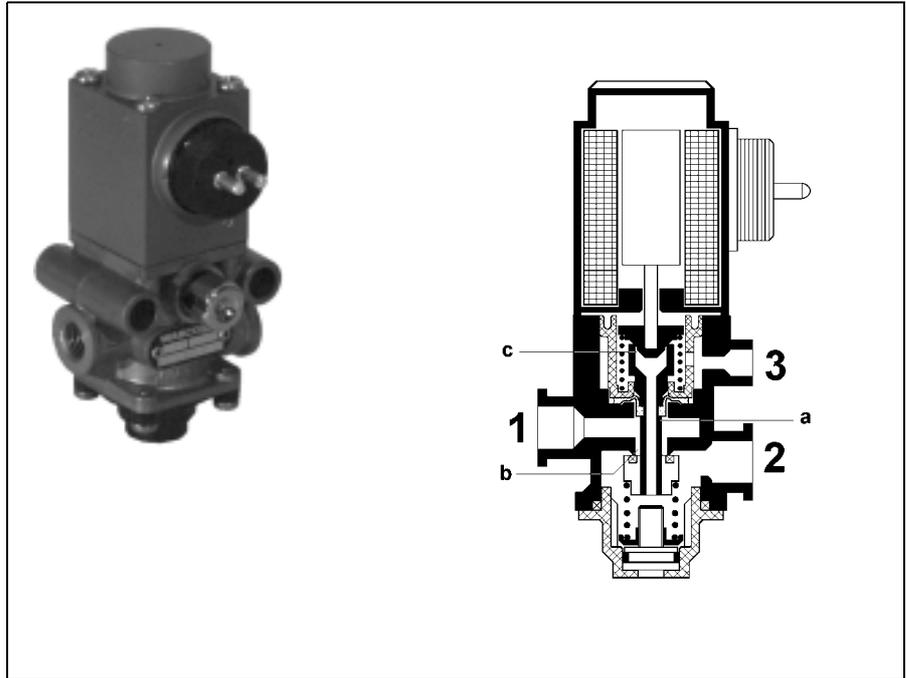
The clamping bush has 4 spring elements held on one side only which, when under stress, generate a force between sensor and hole causing defined frictional engagement in the direction of the sensor.

This causes the sensor to be hold by the clamping bush in such a way that when it is being fitted it can be pushed against the pole wheel and automatically adjusts to a minimum gap when the vehicle is in

motion. This eliminates the process of having to adjust the gap and aligning the sensor (cable exit).

In open arrangements, the clamping bush and the sensor are fitted with a temperature and splash-resistant grease (Staburags or silicone grease - Part No. 830 502 06. 4) to protect them from corrosion and dirt.

**Proportional Solenoid Valve**  
**472 250 . . . 0 (GB<sub>Prop</sub>)**



**Purpose:**

Via the pressure allowed to pass by the actuating cylinder, the proportional valve controls the control lever of the fuel-injection pump.

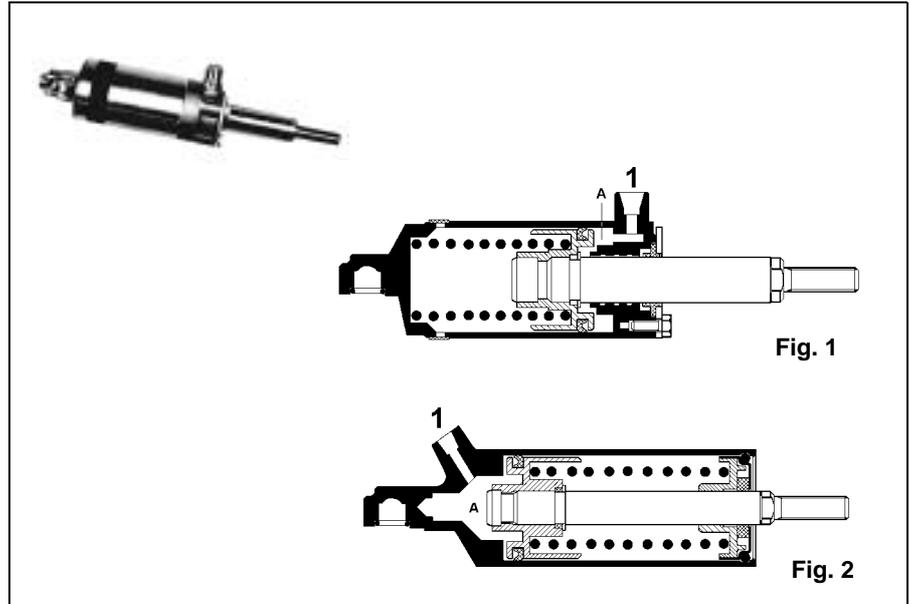
The output pressure is directly proportionate to the solenoid flux controlled by the ECU (GB<sub>Prop</sub>) by means of pulse-width modulation (PWM) with which the proportional valve is actuated. The low hysteresis permits a wide range of cylinder pressures to achieve both very rapid and virtually stationary adjusting movements for the control lever.

**Operation:**

In the basic position (valve solenoid not energized), the solenoid armature is in contact with the plunger (a) and keeps the inlet (b) closed.

When current reaches the solenoid, the armature forces the plunger (a) downwards, opening the inlet (b). The air supply at Port 1 now flows through Port 2 and on to the actuating cylinder. Depending on the pulse output by the ECU, the pressure in the actuating cylinder is either held at a constant level (armature attracts, closing the inlet) or reduced (armature continues to attract, opening the outlet (c) and the compressed air escapes to atmosphere through Port 3).

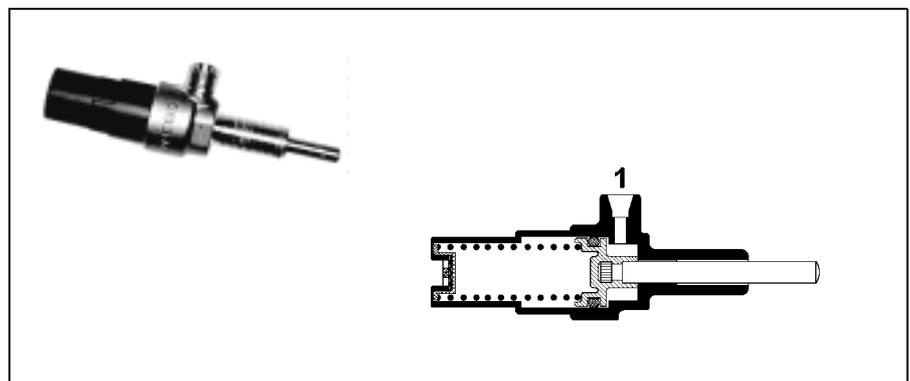
**Operating Cylinder  
(Actuating Cylinder)  
421 44. . . . 0 (GB<sub>Prop</sub>)**



The actuating cylinder is fitted in the adjusting linkage between the accelerator and the fuel-injection pump. When actuated from the proportional valve, the compressed air flows through Port and into Chamber A, moving the piston towards the left. The piston rod which is now being retracted causes the control

lever of the fuel-injection pump to be moved towards its idling position. Depending on the space available for installation, either retracting (Fig. 1) or protruding (Fig. 2) operating cylinders are used.

**Operating Cylinder  
(Idle-Stop Cylinder)  
421 444 . . . 0 (GB<sub>Prop</sub>)**



For single-lever fuel-injection pumps, an idle-stop cylinder is required to prevent the engine being switched off by the speed limiter if the pump lever can be brought to the zero-delivery position by the actuating cylinder.



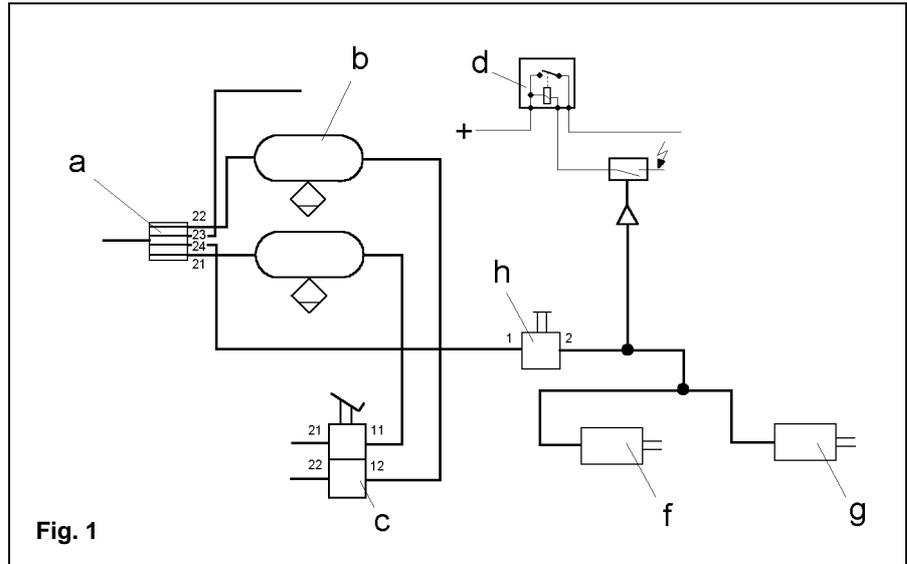
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# **Sustained-Action Braking Systems On Motor Vehicles**

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### Legend:

- a quadruple system protection valve
- b air reservoir
- c towing vehicle foot brake valve
- d operating current relay
- f operating cylinder for fuel injection pump
- g operating cylinder for the exhaust butterfly valve
- h 3/2-way valve



According to Section 41 of the German Motor Vehicle Construction and Use Regulation, motor coaches with a permissible total weight in excess of 5.5 t and other motor vehicles with a permissible total weight in excess of 9 t have to have an additional sustained-action braking system fitted. Sustained-action brakes are engine brakes or systems which achieve a similar braking performance.

The purpose of an engine brake is to

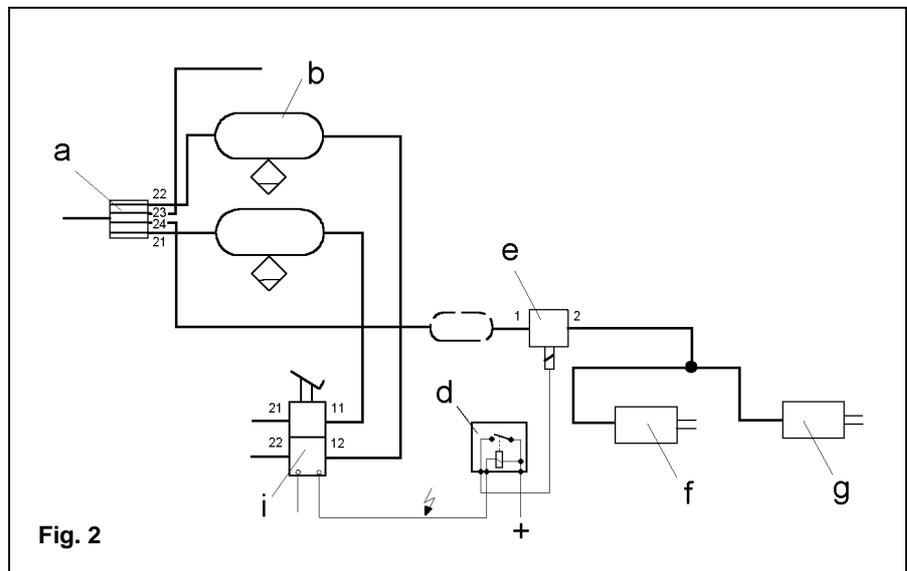
brake the towing vehicle independently from the service braking system, thereby reducing the wear on the mechanical foundation brake to the greatest possible extent.

### Fig. 1:

The engine brake is switched on by means of a foot-operated three-way valve (h) which supplies air pressure for the operating cylinders for the butterfly valve and the fuel-injection pump.

### Legend:

- a quadruple system protection valve
- b air reservoir
- d operating current relay
- e 3/2-way solenoid valve
- f operating cylinder for fuel injection pump
- g operating cylinder for the exhaust butterfly valve
- i towing vehicle foot brake valve with an electrical switch



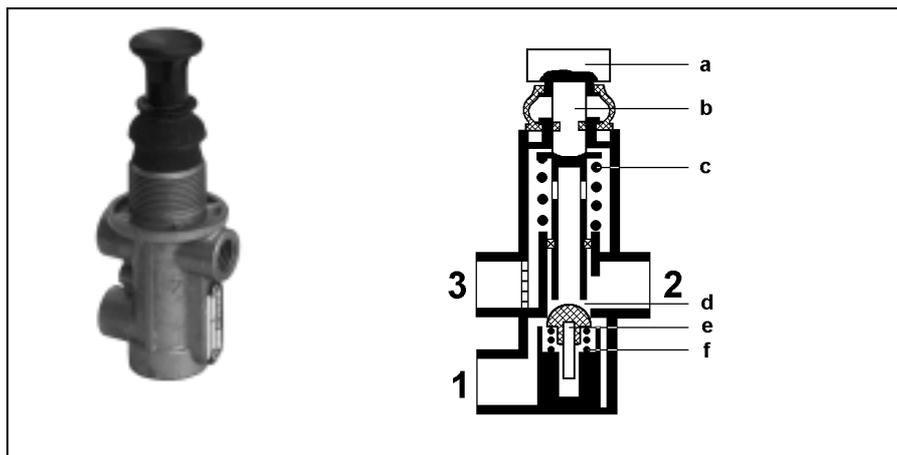
### Fig. 2:

Circuit for the electro-pneumatic engine brake in combination with the service braking system operated by compressed air.

Upon application of the dual-circuit brake valve (i), the electrical switch of the brake valve activates the engine brake via the

operating contact relay (d) and the 3/2-way solenoid valve (e). This means that it is activated every time the service braking system is being used, thus supporting the air brake and reducing the wear on the mechanical foundation brake to the greatest possible extent.

## 3/2-Way Valve 463 013 . . . 0



### Purpose:

To pressurise and exhaust operating cylinder e. g. exhaust braking system.

### Operation:

The compressed air arriving from the air reservoir flows through Port 1 and reaches the 3/2-way valve, until it reaches the underside of the closed inlet valve (e). When the actuating button (a) is pushed down, the plunger (b) is forced downwards against the force of the pressure spring (c) until it makes contact with the inlet valve (e), closing the outlet (d) and, as it continues to move downwards, opening the inlet valve (e). The com-

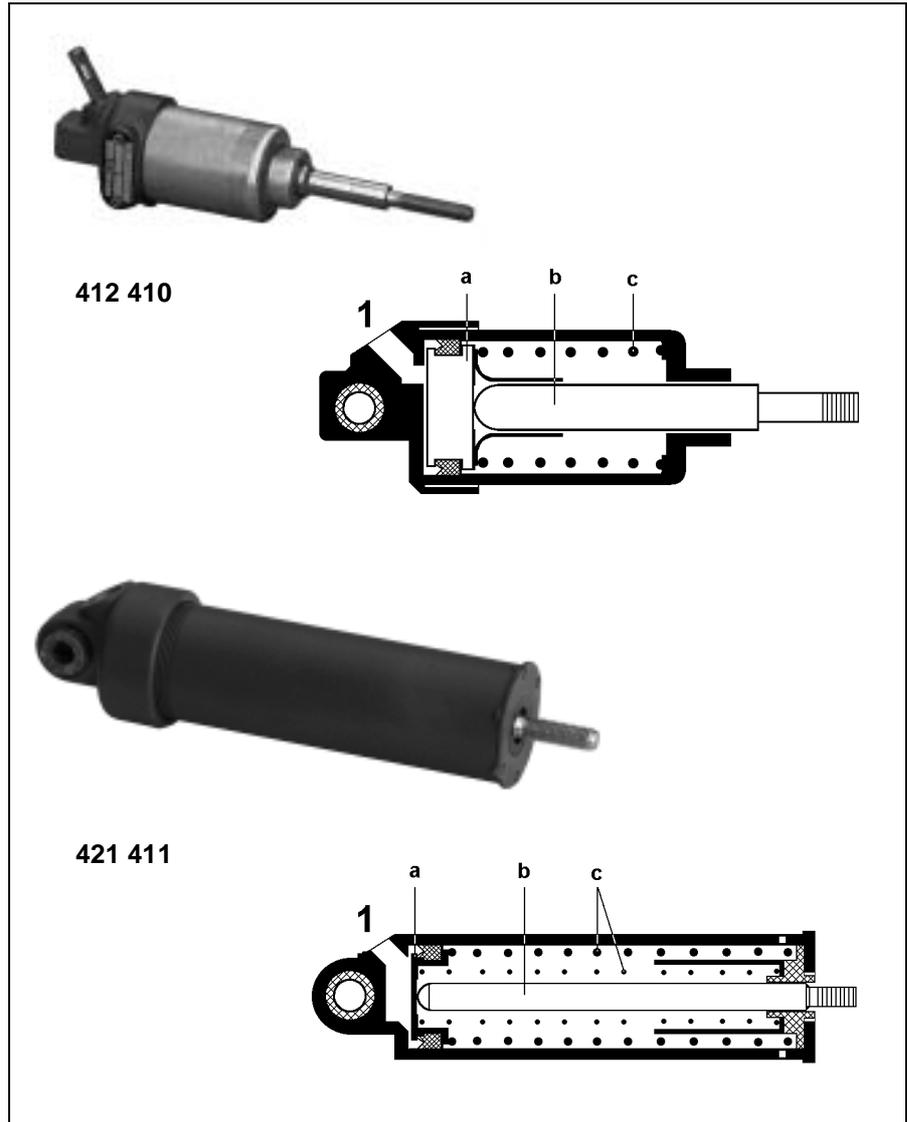
pressed air now flows through Port 2 to the downstream operating cylinders.

When the actuating button (a) is released, the pressure spring (c) forces the plunger (b) back into its upper end position. Pushed by the supply pressure and the pressure spring (f), the inlet valve (e) follows the upward motion of the plunger (b) and closes the passage to Port 1. Through the opening outlet (d) the compressed air from Port 2 now flows to Port 3 and the operating cylinders are evacuated once again.

# 4.

## Sustained-Action Braking Systems On Motor Vehicles

### Air Cylinder 421 410 . . . 0 and 421 411 . . . 0



#### Purpose:

Shutting off the fuel injection pump and operating the butterfly in the exhaust brake system.

#### Operation:

Air enters the cylinders from either the 3 way valve or the 3 way magnet valve through port 1. As pressure builds up behind piston (a) the push rod (b) moves outwards against the load of springs (c).

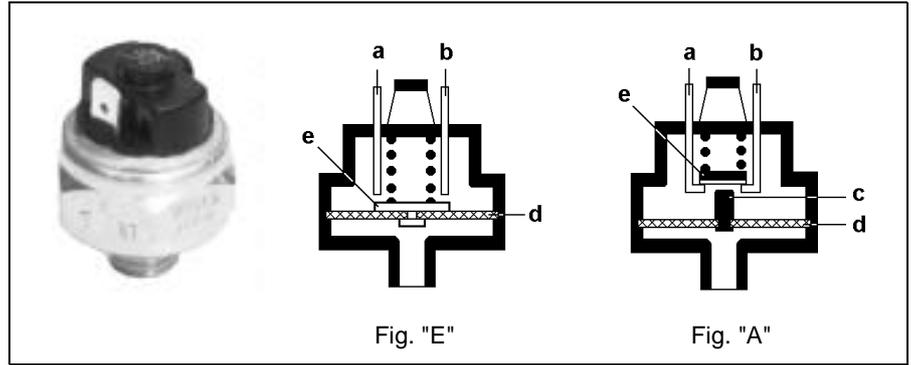
Cylinder 421 410 . . . 0 is connected to the lever on the fuel injection pump, so that when operated, the lever moves from the "idle" position to the "stop" posi-

tion. The cylinder is also connected into the throttle linkage, so that as long as the exhaust brake is in operation, it is impossible to depress the accelerator pedal.

Cylinder 421 411 . . . 0 is connected to the butterfly in the exhaust pipe, so that when operated, the butterfly closes. The back pressure created in the engine gives a braking effect to the vehicle.

When the cylinders are exhausted, the springs (c) push the piston (a) back to its original position.

## Pressure Switch 441 014 . . . 0



### Purpose:

To switch on or off electrical units and lamps according to the application.

### Operation:

Application "E" (normally open)  
On reaching the switch pressure the diaphragm (d) together with the contact plate (e) is raised and a connection at the poles (a and b) is made.

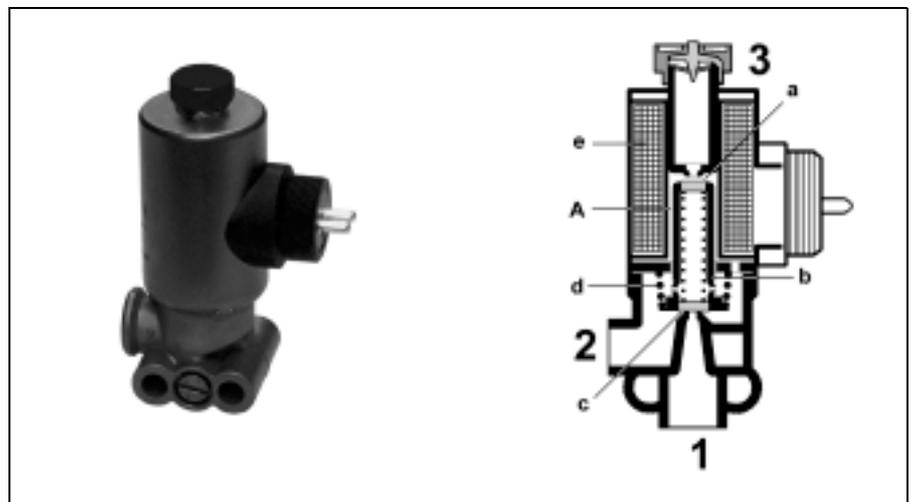
With a pressure fall this connection is again interrupted.

### Application "A" (normally closed)

On reaching the switch pressure the diaphragm (d) is raised together with the tappet. The tappet (c) lifts the contact plate (e) and the connection at the poles (a and b) is interrupted.

With a pressure fall this connection is re-made.

## 3/2-Way Solenoid Valve Normally Closed 472 170 . . . 0



### Purpose:

To pressurize an air line when current is supplied to the solenoid.

### Operation:

The supply line from the air reservoir is connected to port 1. The armature (b) which forms the valve core keeps inlet (c) closed by the load in pressure spring (d).

When a current reaches solenoid coil (e), armature (b) is lifted, outlet (a) is closed

and inlet (c) is opened. The compressed air from the supply line will now flow from port 1 to port 2, pressurizing the working line.

When the current to solenoid coil (e) is interrupted, pressure spring (d) will return armature (b) to its original position. Inlet (c) is closed, outlet (a) is opened and the working line is exhausted via chamber (A) and exhaust 3.



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# **EBS - Electronically Controlled Braking System**

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## Introduction:

Increasing competition in the transport trade has also caused the requirements for braking systems to be increased steadily. The introduction of the Electronically controlled Braking System EBS is the logical step to meet this and other requirements. EBS permits perpetual optimized balancing of the braking forces among the individual wheel brakes, and of the towing vehicle and its trailer.

The comprehensive diagnostic and monitoring functions of the Electronically controlled Braking System are one of the basic requirements for effective fleet logistics. EBS enhances vehicle and road safety by means of reducing the stopping distance, achieving improved braking stability and monitoring the braking system. In addition, EBS considerably improves both economic efficiency and driving comfort.

## Benefits of EBS

### EBS Effectively Reduces Maintenance Costs.

□ EBS combines a large number of functions. The objective is to reduce maintenance costs whilst maximizing braking safety, e.g. by minimizing lining wear of the wheel brakes.

□ Individual control according to the wear criteria on both front and rear axles harmonizes lining wear. By evenly spreading the load across all wheel brakes, total wear is minimized. In addition, maintenance and lining change intervals coincide. Laid-up costs are drastically reduced.

## System Design

For this reason, EBS will be included in new vehicle series, the pioneer being ACTROS from Daimler-Benz which has an electronically controlled air braking system fitted as standard equipment. This system by name of "Telligent® Braking System" from Daimler-Benz (formerly EPB), is a joint development by Daimler-Benz and WABCO.

### Please note:

The term "Telligent® Braking System" comprises the whole of the braking system, not only its controlling system which we call EPB.

The ACTROS "Telligent® Braking System" contains some specific Daimler-Benz features for which WABCO, in applications for vehicles from other manufacturers, has substituted its own solutions. These include the following functions described in the publication in more detail:

- redundancy valve, rear axle redundancy
- special control functions in the area of brake force distribution (differential, drive-slip control DSR), lining wear control and trailer control
- testing and diagnostic methods typical for ACTROS.

### Modular Design of WABCO EBS

The configuration and the structure of WABCO's EBS permits a high degree of flexibility for the vehicle manufacturer

when designing the system. For this reason, the most varied of needs can be met:

- partial or full system,
- type of redundancy,
- trailer control strategy,
- electrical interfaces, etc.

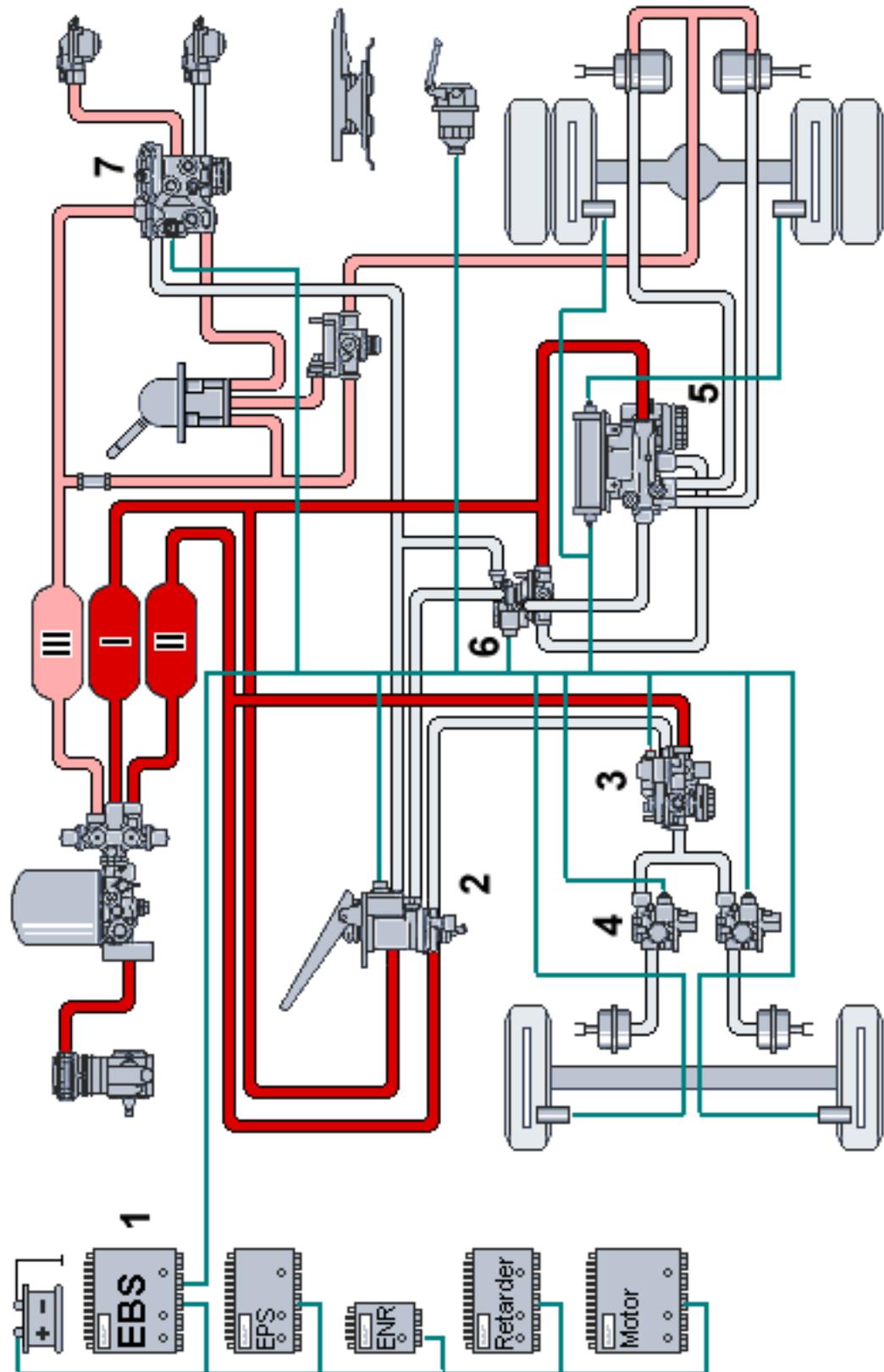
For meeting the essential requirements of the vehicle owner, WABCO recommends an EBS which comprises individual pressure control on front and rear axles and trailer control, and which provides for pneumatic redundancies in all braking circuits.

This EBS consists of a dual circuit and an overriding single-circuit electro-pneumatic circuit. This configuration is described as 2P/1E-EBS.

The single circuit electro-pneumatic part of the system consists of one central electronic control unit (central module), the axle modulator with integrated electronics for the rear axle, a brake signal transmitter with purely pneumatical integrated stroke sensors and brake switches, an electro-pneumatic control valve and two ABS valves for the front axle, plus an electro-pneumatic trailer control valve.

An expansion of this configuration by an additional axle modulator for the rear axles would then provide a 6-channel EBS. The structure of the subordinate dual-circuit pneumatic part of the system is basically identical with that of a conventional braking circuit. This part of the system serves as a backup and becomes effective only if the electro-pneumatic circuit fails.

EBS Brake System for Track 4x2:



Legend:

1 Central Module

2 Brake Signal Transmitter

3 Proportional Relay Valve

4 Solenoid Modulator Valve - ABS

5 Rear Axle Modulator

6 Backup Valve

7 Trailer Control Valve

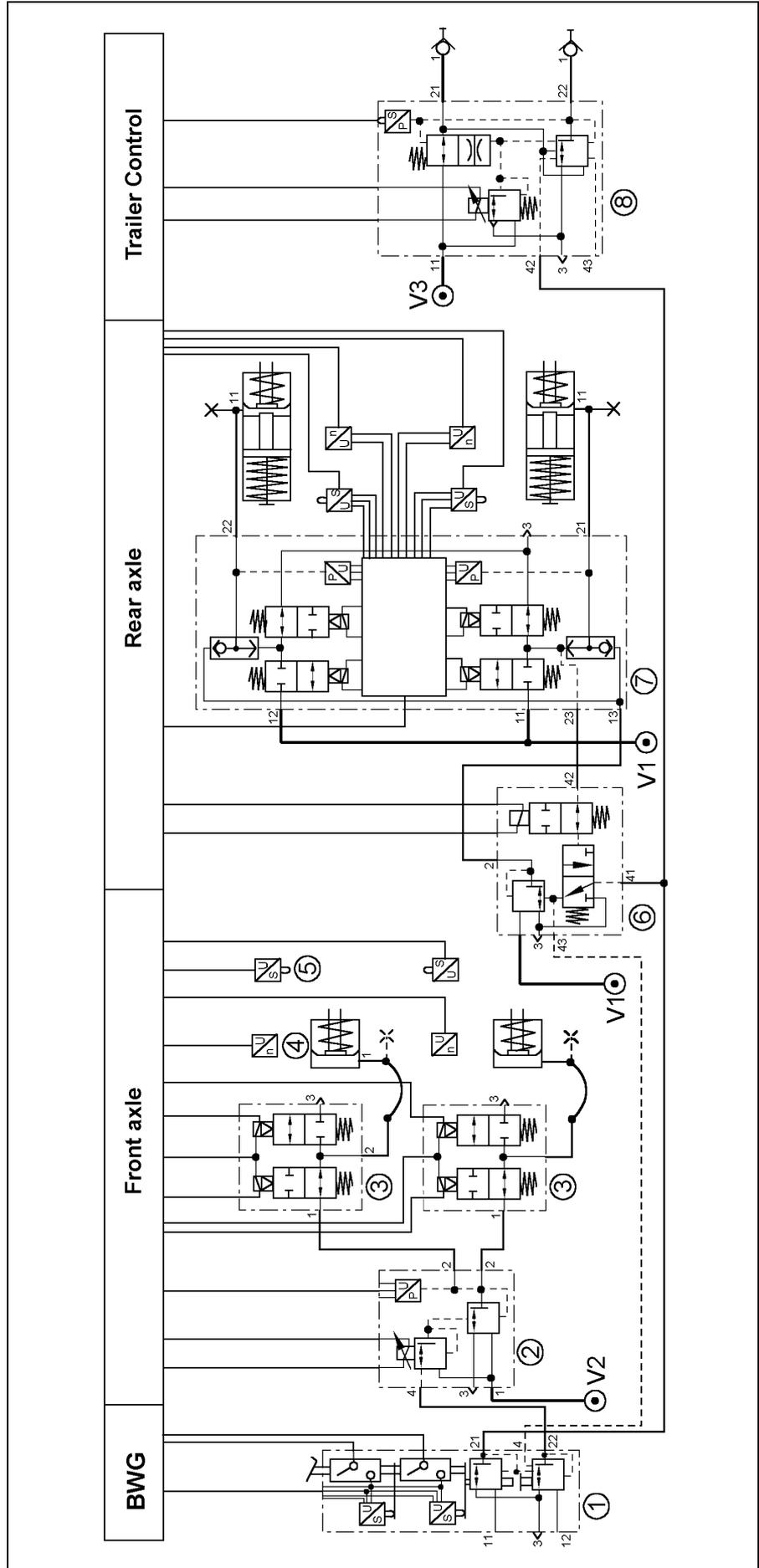
# 5.

## EBS - Electronically Controlled Braking System

### Function Scheme:

#### Legend:

- 1 Brake Signal Transmitter (BWG)
- 2 Proportional-Relay Valve
- 3 Solenoid Modulator Valve - ABS
- 4 Speed Sensor
- 5 Wear Sensor
- 6 Backup Valve
- 7 Rear Axle Modulator
- 8 Trailer Control Valve

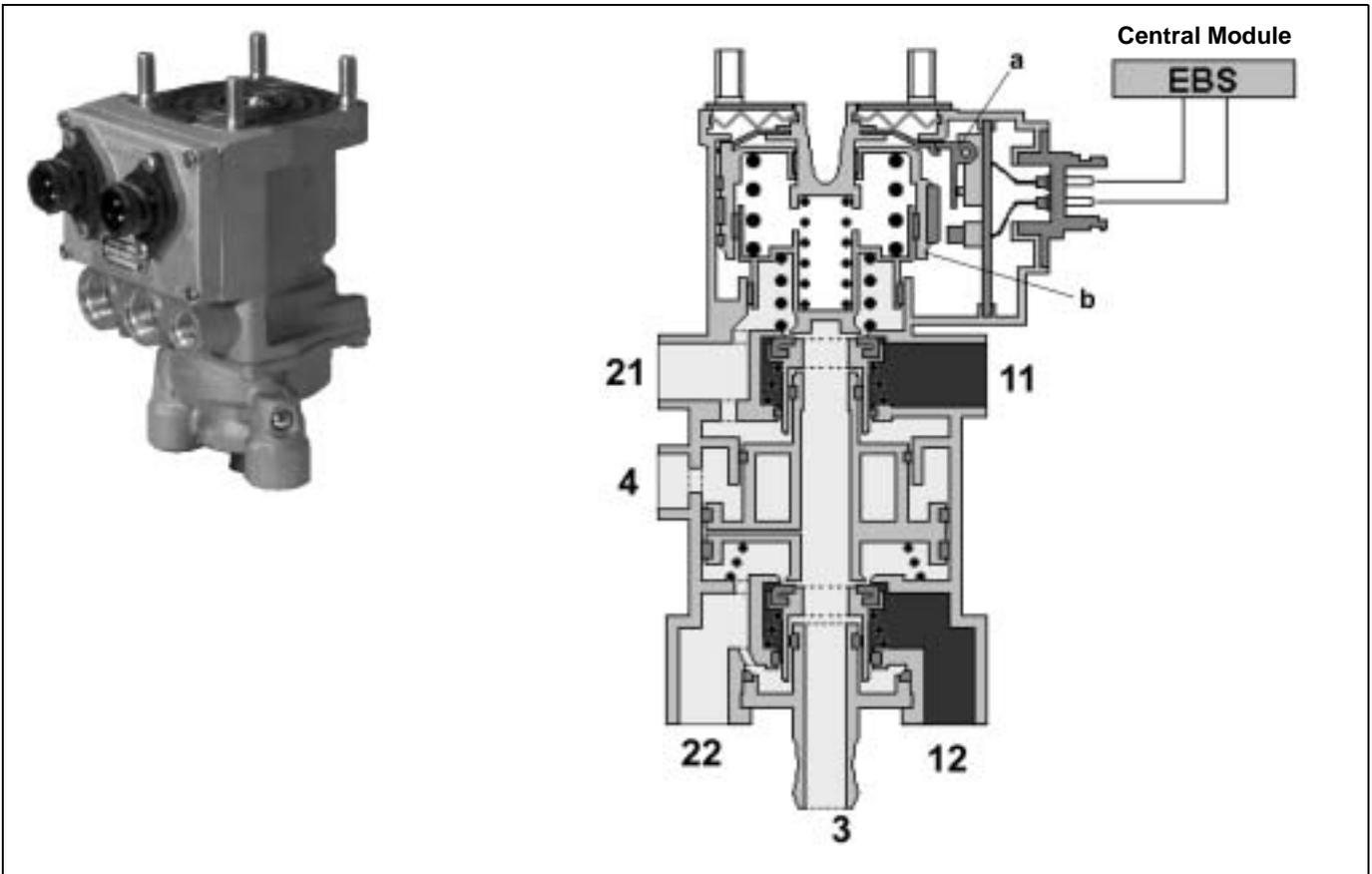


## Central Module 446 130 . . . 0



The central module is used to control and monitor the Electronically controlled Braking System. From the signal received from the brake signal transmitter it determines the vehicle's intended retardation. Together with the wheel speeds measured by the wheel speed sensors, the intended retardation is the input signal for EBS control which uses these readings to establish the index pressure values for the front and rear axles and the trailer control valve. The index pressure for the front axle is compared with the actual value taken, and any differences are balanced by means of the proportional relay valve.

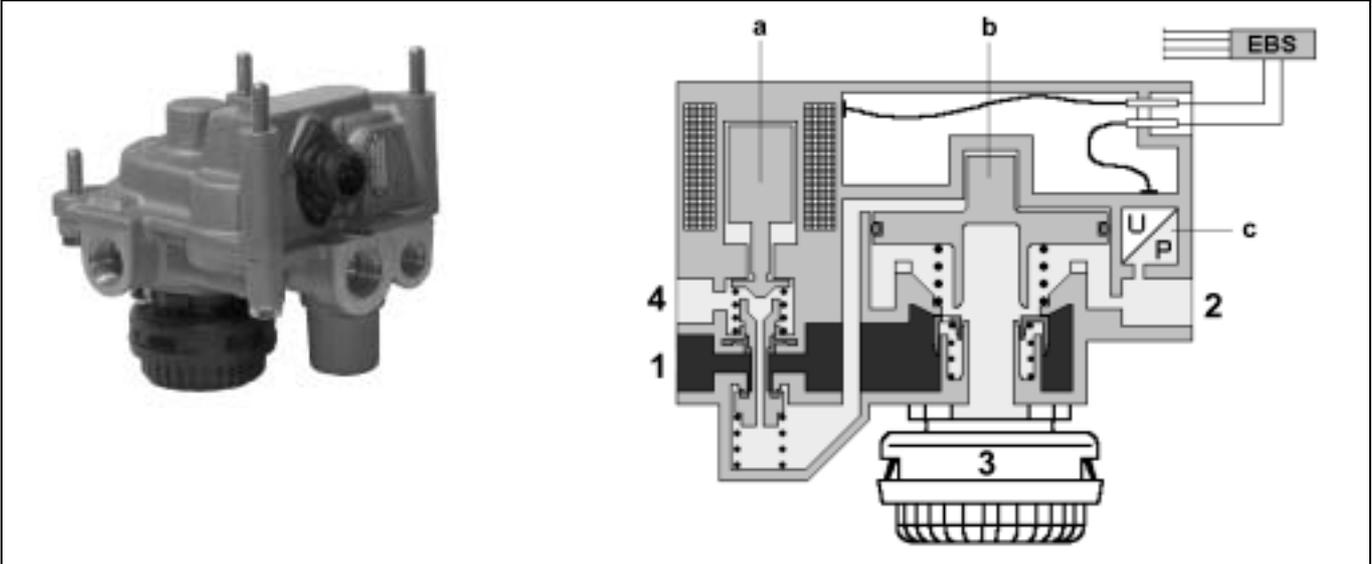
Output of the trailer control pressure is achieved in a similar manner. In addition, the wheel speeds are evaluated to commence ABS control by modulating the brake pressures in the brake cylinders in the event of the wheels showing a tendency to lock. The central module exchanges data, via the EBS system bus, with the axle modulator (or axle modulators in 6S/6M systems). Electrical braking systems for trailers are actuated via a data interface to ISO 11992. The central module communicates with other systems of the towing vehicle (engine control, retarder, etc.) via a vehicle data bus.



## Brake Signal Transmitter 480 001 . . . 0

The brake signal transmitter is used to generate electrical and pneumatic signals to apply to, or release pressure from, the Electronically controlled Braking System (EBS). This unit is designed for two pneumatic and electrical circuits respectively. Commencement of actuation is electrically recorded. The start of actuation is electrically perceived by a double switch (1). The travel of the actuating plunger (b) is picked up and results in the pulse-width modulated output as

an electrical signal. In addition, the pneumatic redundancy pressures in Circuits 1 (Port 21) and 2 (Port 22) are transmitted, that of Circuit 2 being retained slightly. Via an additional pilot connection 4 it is possible (at a customer's specific request) to adjust the pneumatic characteristic of the 2nd circuit. In the event of one circuit failing (electrical or pneumatic), the other circuits remain operational.



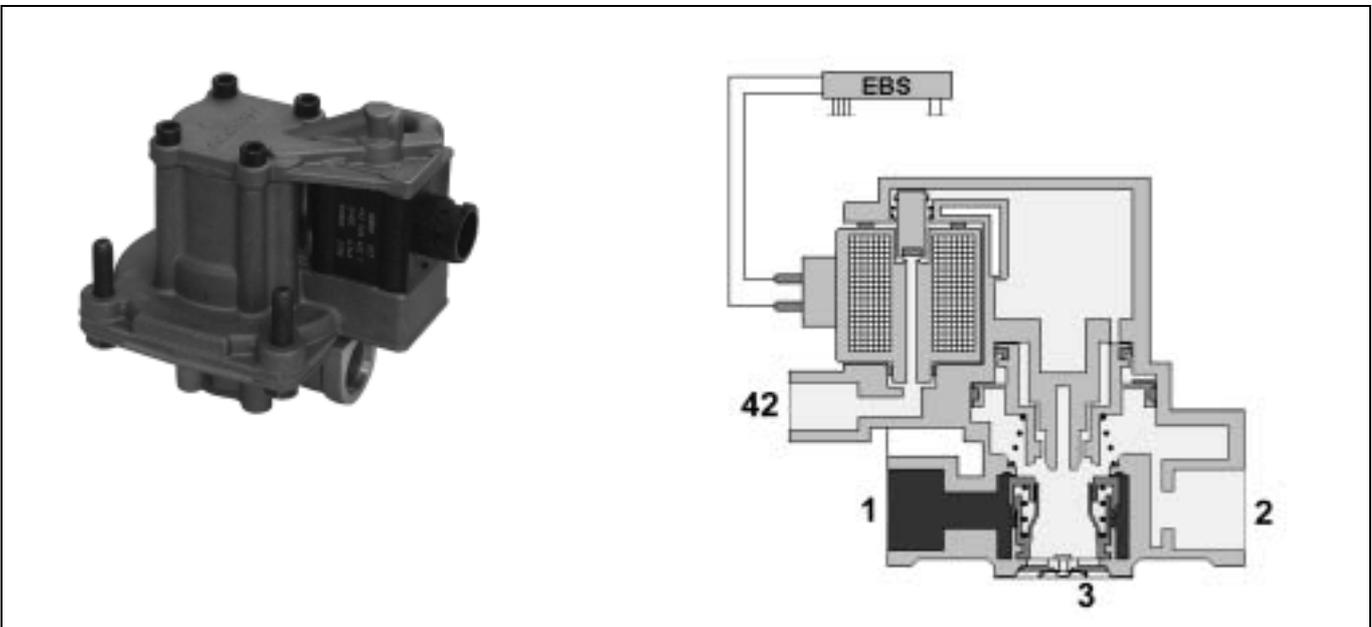
### Proportional Relay Valve 480 202 ... 0

In the Electronically controlled Braking System, the proportional relay valve is used as an actuator for the output of brake pressures at the front axle.

It consists of a proportional solenoid valve (a), a relay valve (b) and a pressure sensor (c). Electrical actuation and monitoring are effected by the central module of the hybrid system.

The control current determined by the electronics is converted by the propor-

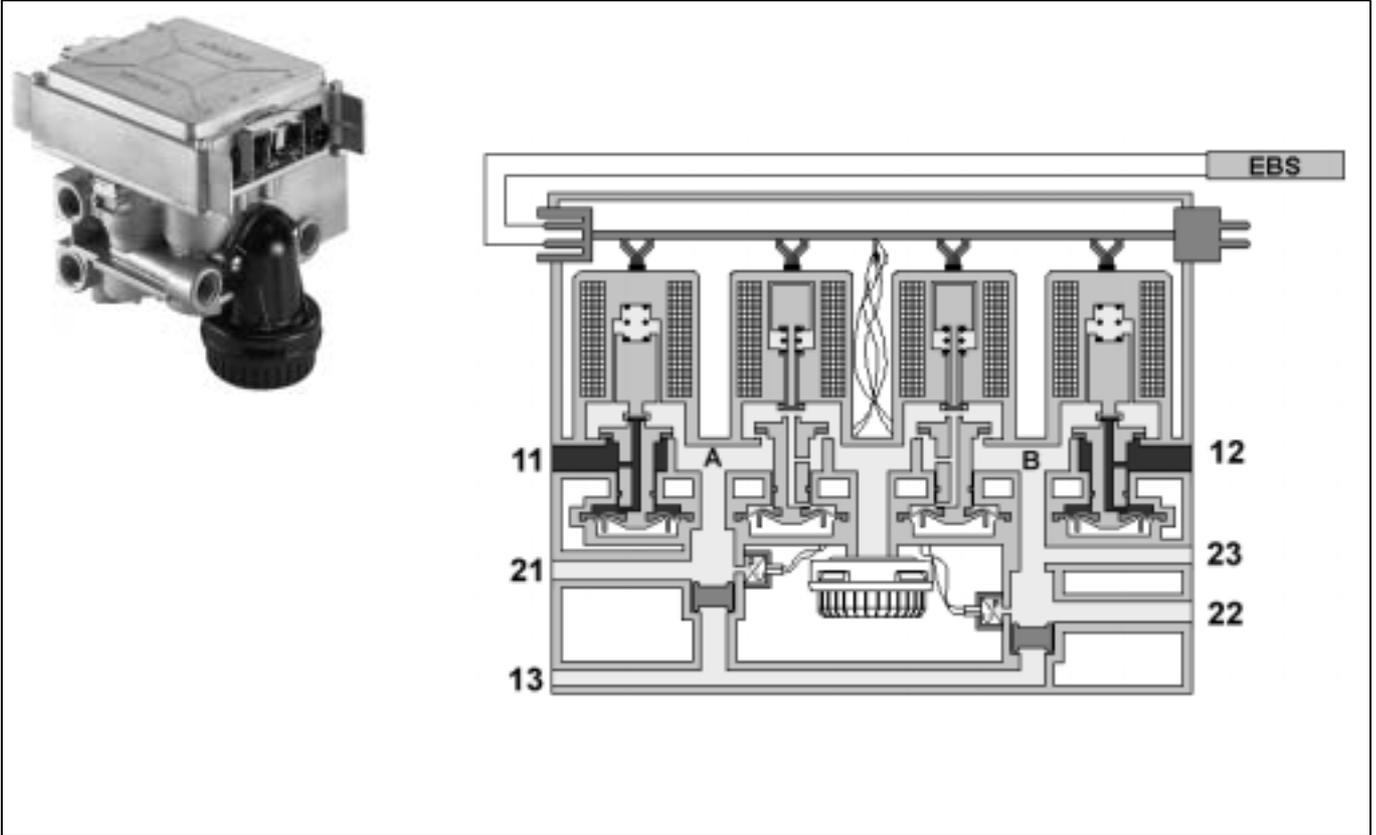
tional relay valve (a) into control pressure for the relay valve. The output pressure (port 2) of the proportional relay valve is proportional to that pressure. The pneumatic actuation of the relay valve (port 4) is effected by the redundant pressure of the brake signal transmitter (port 22).



### Backup Valve 480 205 ... 0

The backup valve is used to rapidly increase or decrease the pressure for the brake cylinders on the rear axle in the case of a backup; it consists of several valve units which have to perform the following functions, among others:

- 3/2-way valve to prevent backup operation if the electro-pneumatic braking circuit is not defective
- relay valve function for improving the time response of the backup
- pressure retention in order to synchronize the commencement of pressure output on the front and rear axles in the event of a backup
- pressure reduction to avoid overbraking of the rear axle to the largest possible extent in the case of a backup.



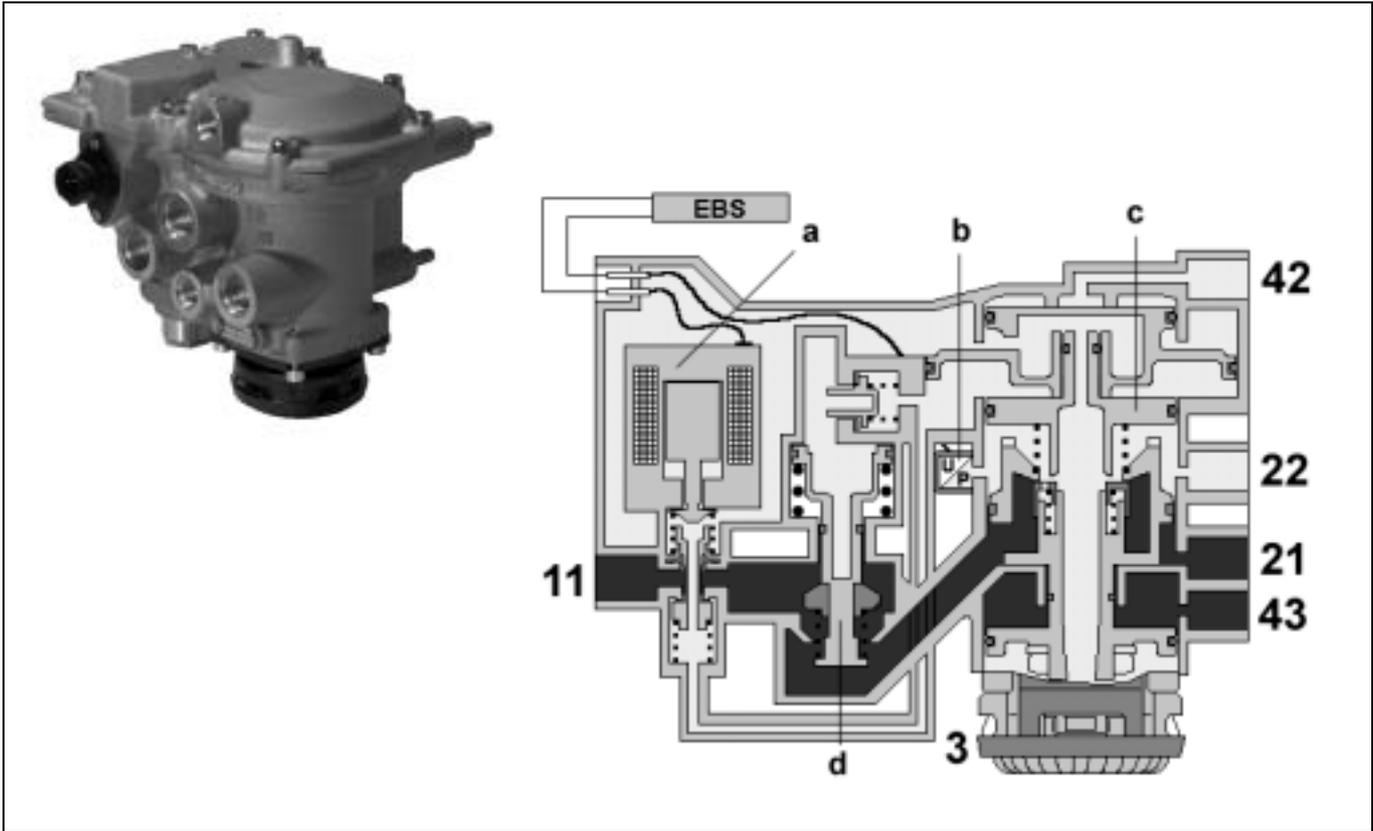
## Axle Modulator 480 103 . . . 0

The axle modulator controls the brake cylinder pressures on both sides of one or two rear axles. It contains two independent pneumatic pressure control channels (Channels A and B), each containing one inlet and one exhaust valve, plus one pressure sensor, sharing one electronic control unit. The index pressures and external monitoring functions are provided by the central module.

In addition, two speed sensors monitor and evaluate the wheel speeds. In the event of a tendency to lock or to spin being detected, the index value provided is adjusted.

Two sensors can be connected for monitoring lining wear.

The axle modulator has one additional port for connecting a backup pneumatic braking circuit. One double check valve per side transmits the higher of the two pressures (electro-pneumatic or redundant) to the brake cylinder.



### Trailer Control Valve 480 204 . . . 0

In the Electronically controlled Braking System, the trailer control valve is used as a control element to output the hose coupling pressures.

The trailer control valve consists of a proportional solenoid valve (a), a relay valve (c), a breakaway emergency valve (d) and a pressure sensor (b). Electrical actuation and monitoring are effected by the central module.

The control current determined by the electronics is converted by the propor-

tional solenoid valve into control pressure for the relay valve. The output pressure of the trailer control valve is proportional to that pressure.

The pneumatic actuation of the relay valve is effected by means of the backup pressure from the brake signal transmitter (port 42) and the output pressure from the hand brake valve (port 43).

## EBS On The Trailer

The scheme on page 64 and 65 each show EC air braking systems widely used in Europe today. On a semitrailer, this braking system essentially consists of a relay emergency valve, a load-sensing valve and the ABS.

In the Vario-Compact System shown here, the ABS relay valves and the electronic control unit have been combined. Frequently, however, these components are fitted separately. On the drawbar trailer, another load-sensing valve, a third ABS relay valve, an adapter valve on the front axle and a pressure limiting valve on the rear axle are added to the components listed above. Although this EC braking system is now highly sophisticated, especially through the use of ABS, there is still room for the improvements listed below:

- Reduction of the variety/number of components and thus installations costs.
- Dispensing with the required air val-

ves and their adjustment by introducing electronic control and the simple setting of parameters this permits.

- By using pressure control circuits which operate with a high degree of precision, it is possible to almost completely eliminate the deviations in characteristics encountered today.
- The "electrical brake line" and electronic control can considerably improve the time response and thus contribute towards reducing the stopping distance and improving the stability of the tractor-trailer combination.
- Extending the diagnostic features for the whole of the braking system, including maintenance and repair instructions.

It was these possible improvements which provided the basis for the development of an electronically controlled EBS on the trailer

## EBS For Semitrailers 4S/2M

- 1 EBS relay emergency valve
- 2 EBS trailer modulator
- 3 ABS sensor
- 4 axle load sensor
- 5 pressure sensor
- 6 pressure switch
- 7 redundancy valve

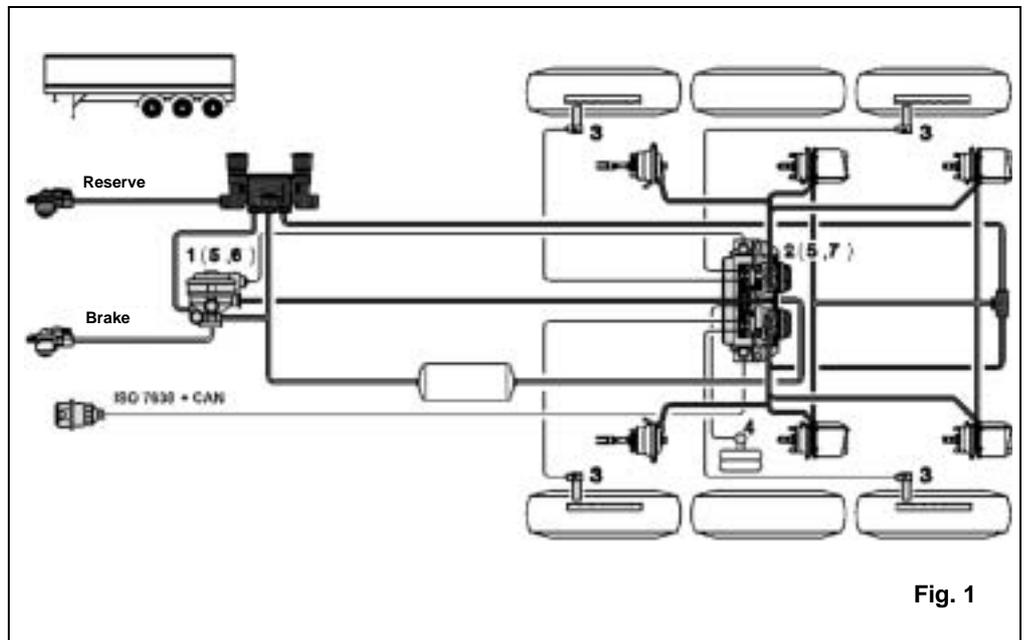


Fig. 1

### System Description

Fi. 1 shows the standard EBS for a 3-axle semitrailer. It electronically controls lateral braking pressures. The system consists of a compact dual-circuit trailer modulator with a digital data interface to ISO 1199-2 to the EBS towing vehicle, an EBS relay emergency valve, an axle load sensor and ABS sensor. When used

on drawbar trailers or semitrailers with a steering axle, a system is needed which includes an additional EBS relay valve on the steering axles, see Fig 2.

Trailers with the electronic braking system described must be compatible with both conventional towing vehicles and towing vehicles which use EBS, allowing

## EBS - Electronically Controlled Braking System

pneumatic redundant braking in the event of EBS failure.

This results in three possible types of operation:

### Operation with new towing vehicles with EBS and extended ISO-7638 plug-in connection with CAN interface.

All EBS functions can be utilized. The trailer receives the index values from the towing vehicle via the data interface.

### Operation with conventional towing vehicles with ISO-7638 plug-in connection for the trailer's ABS supply but with no CAN interface

All EBS functions can be utilized, with the exception of the transmission of the index values via the CAN data interface.

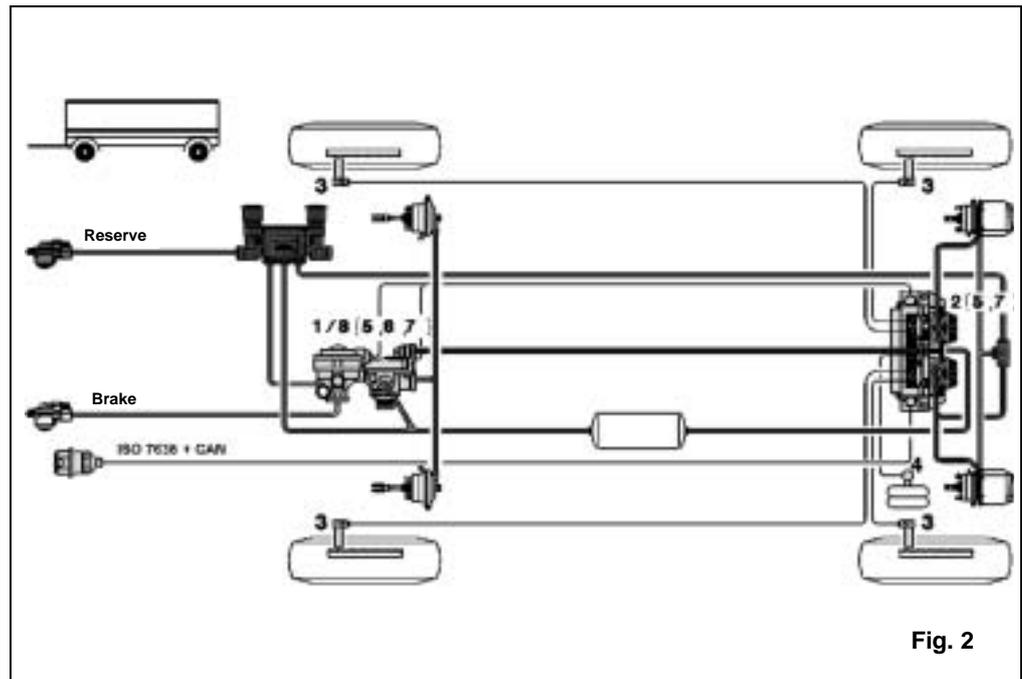
The index values are provided by the pressure sensor in the relay emergency valve which picks up the actuating pressure for the trailer.

### Redundancy Operation

In the event of a failure of the electrical voltage supply, ordinary pneumatic braking can always be achieved, although with no load-sensing or ABS functions. In redundancy operation, the time response is similar to that of today's conventional braking systems. If the EBS trailer is operated pneumatically, an improved time response is achieved since electrical sensing of the actuating pressure saves time. When used with an EBS towing vehicle and actuation via CAN, the pressure in the EBS trailer builds up almost simultaneously with that in the towing vehicle.

### EBS For Drawbar Trailers 4S/2M

- 1 EBS relay emergency valve
- 2 EBS trailer modulator
- 3 ABS sensor
- 4 axle load sensor
- 5 pressure sensor
- 6 pressure switch
- 7 redundancy valve
- 8 EBS relay valve



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# **Air Suspension Systems And ECAS (Electronically Controlled Air Suspension)**

---

In commercial vehicles and motor coaches, more and more air-suspensions are being used.

In commercial vehicles with interchangeable platforms they achieve a considerable reduction in loading and unloading times. On coaches, ride comfort is improved by means of the spring force being adjusted to the number of passengers travelling on the coach and a boarding level which remains the same at all times.

### Air Suspension System

When planning and designing air suspension systems, the following system types have been used to date:

- a) air suspensions with a closed air circuit
- b) air suspensions with a semi-closed air circuit
- c) air suspensions with an open air circuit.

The systems mentioned under a) and b) are mainly used in passenger cars, their benefit being that they consume a small amount of air so that the compressor can be smaller due to its lesser delivery requirements. In addition, there is little condensate or dirt. Such systems are, however, technically complex and fairly expensive to buy.

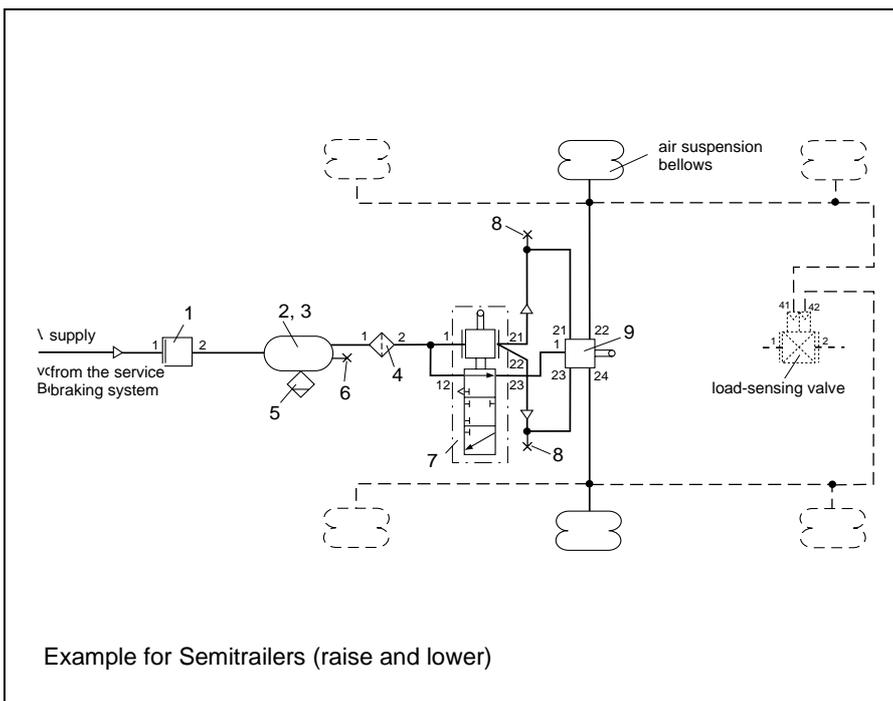
For that reason, motor coaches and commercial vehicles use air suspension systems with an open air circuit. Since this system evacuates air which is not required back to atmosphere, the air compressor has to be larger. This type of air suspension system is straightforward in terms of its circuit and the valves it uses.

Of course neither types of suspension (mechanical spring suspension elements or air suspension systems) can meet all technical requirements. Comparing both system types, however, shows that air suspensions offer significant advantages over mechanical suspensions. This applies especially where the wheel suspension elements are to be separated from other suspension members to achieve better road holding qualities.

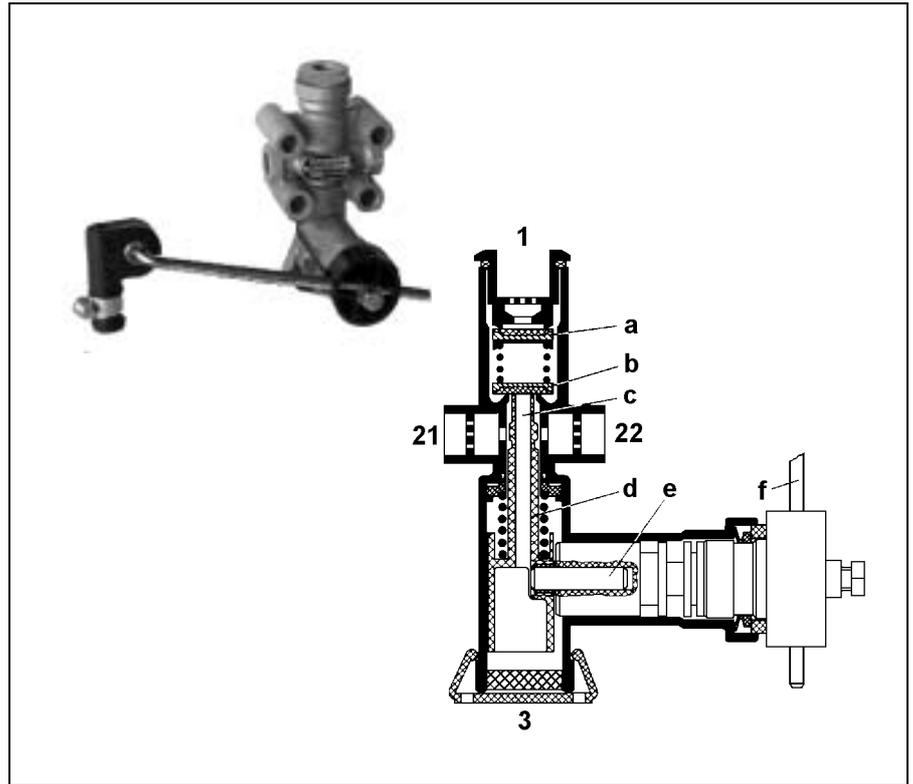
### Benefits of Air Suspension Systems

1. By adjusting the bellows pressure as a ratio of the load carried, the distance between the road surface and the vehicle's superstructure will always be the same. This means that not only is the boarding or loading level constant, but also the headlight setting.
2. Due to the adjusting pressure in the bellows, spring comfort is not subject to any major changes, regardless of the load carried. The passenger on a motor coach will always perceive the same pleasant type of oscillation. Sensitive loads are carried without any major damage. An empty or partially laden vehicle will no longer 'jump'.
3. Both steering stability and the transmission of brake forces are improved since tyre-road adhesion is always achieved for all wheels.
4. The pressure in the air suspension bellows which is dependent on the load carried is also ideal for controlling load-sensitive braking ('ALB').
5. In interchangeable platform operation, air suspension systems achieve efficient loading and unloading of container vehicles.
6. Protects the road surface.

In an air suspension system, the equipment for air compression, for the storage of compressed air and for pneumatic control must form a unit with the wheel suspension and other elements. The diagram on this page illustrates this for an air suspension system on semitrailers.



## Levelling Valve 464 006 . . . 0



### Purpose:

To control the pressure in the air suspension bellows in proportion to the vehicle load.

Levelling Valve 464 006 100 0 has an additional 3/2 directional control valve which closes from a pre-defined, adjustable lever angle and which takes on an exhaust function when the lever is moved further. This "height limitation" prevents the vehicle being raised above the permissible level by means of the raise/lower valve.

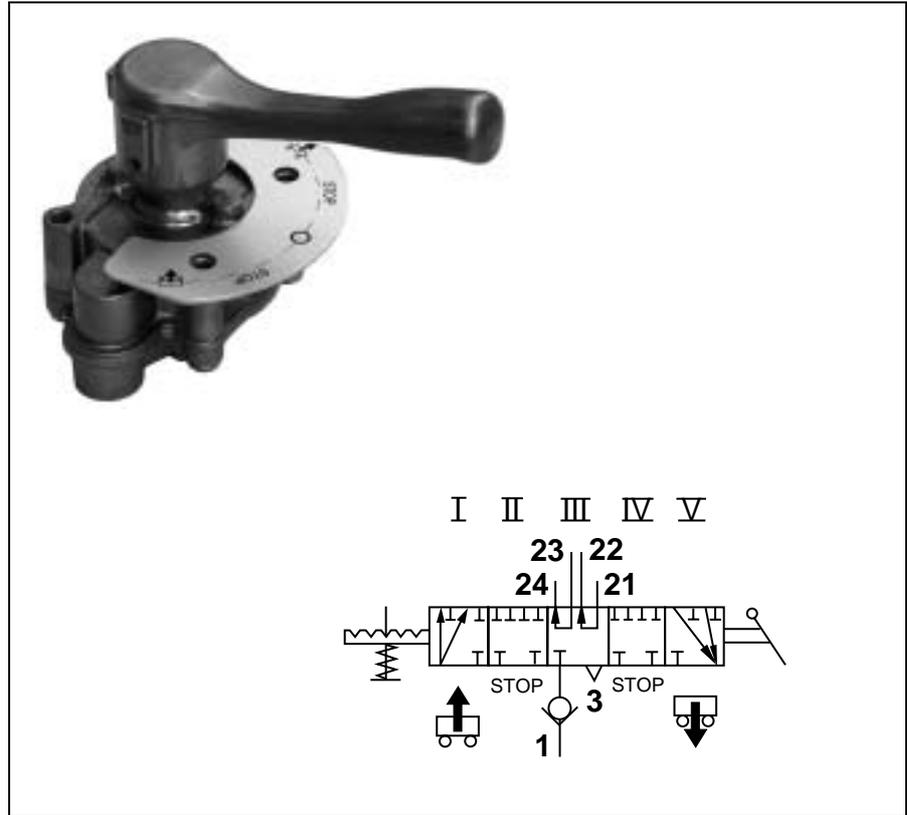
### Operation:

The vehicle body with its levelling valve will move down as the load on the body is increased. The linkage between the vehicle axle and the levelling valve raises both lever (f) and guide (d) via eccentric cam (e). As guide (d) moves up, it also lifts its pin, thus opening inlet valve (b), allowing air from the reservoir to flow through the valve via port 1 and check valve (a) into the air bellows which are connected to ports 21 and 22. In order to minimize air consumption, the outside of the pin is machined in such a way that the passage of air through the valve is regulated at two levels depending on the deflection of lever (f).

As the pressure in the air bellows increases, the chassis height is adjusted, and lever (f) causes inlet valve (b) to close. In this position, ports 21 and 22 are connected to each other via a transverse throttle.

When the vehicle load is decreased, the reverse process takes place. The vehicle chassis is now raised by the excess pressure in the air suspension bellows and lever (f) with eccentric cam (e) and guide (d) are pulled down. This causes the pin to be moved downwards from its seat on inlet valve (b), permitting excess pressure from the air bellows to escape to atmosphere via drilling (c) and vent holes 3. With this drop in pressure in the air bellows, the chassis height is lowered and lever (f) is returned to its normal horizontal position. As drilling (c) is blocked by the pin resting on inlet valve (b), the levelling valve is again in a balanced position.

### Raise/Lower Valve 463 032 . . . 0



#### Purpose:

To raise and lower the chassis of air-sprung semi-trailers and vehicles with interchangeable platforms (lifting facility).

#### Operation:

In the "travelling" position of the hand lever, the lifting mechanism is inoperative. The raise/lower valve allows the free passage of air from the levelling valves (ports 21 and 23) to the air suspension bellows (ports 22 and 24).

The valve also permits four more positions of the hand lever for filling and emptying the air suspension bellows for raising and lowering purposes.

To raise the chassis, the hand lever is unlocked by axial pressure and moved to the "raise" position in which ports 21 and 23 are closed, blocking the action of the levelling valves, while the suspension bellows 22 and 24 are connected to the reservoir by port 1.

When the required lift height has been attained, the hand lever is moved to the

"raise stop" position in which the levelling valve ports 21 and 23 and the suspension bellows ports 22 and 24 are closed. The platform supports can now be swung into position.

It is then necessary to lower the chassis below its normal level to deposit the container or platform on the supports and to drive out the chassis. This is done with the hand lever in the "lower" position. As in the "raise" position, ports 21 and 23 are closed but air suspension bellows 22 and 24 are now exhausted through exhaust port 3.

This operation, too, is terminated by moving the lever to the "lower stop" position. Ports 21, 23, 22 and 24 are closed. Before the vehicle is driven, the hand lever must be moved to the "travelling" position to allow the levelling valves to be re-connected to the air bellows.

## Introduction:

The letters ECAS stand for

Electronically  
Controlled  
Air  
Suspension

ECAS is an Electronically Controlled Air Suspension system for vehicles and includes a large number of functions. The conventional system has been significantly enhanced through the use of an Electronic Control Unit (ECU):

- Reduction of air consumed whilst the vehicle is moving
- It is possible to maintain different levels (e.g. ramp operation) by means of automatic readjustment
- In the case of complex systems, installation is easier
- Additional functions such as traction help, programmable vehicle levels, tyre deflection compensator, overload protection and automatic lifting axle control can easily be integrated
- Due to large valve diameters, pressurizing and venting processes are accelerated
- Easy operation and maximum safety for those operating the system due to one single control unit
- Highly flexible system due to the fact that electronics can be programmed via operating parameters (trailing end programming)

- Clear-cut safety concept and diagnostic facility.

With conventional air suspension systems, the valve which measures the height also controls the air bellows, where as ECAS achieves control by means of an electronic control unit (ECU) actuating the air bellows via solenoid valves, using information received from sensors.

The ECU not only controls the normal height of the vehicle, it also, via the remote control unit, permits control of the other functions which, in conventional air suspension systems, require additional valves such as height adjustment valves and height limiting valves.

Over that, a large number of additional system functions are available

ECAS is adjustable to suit the different types of trailer.

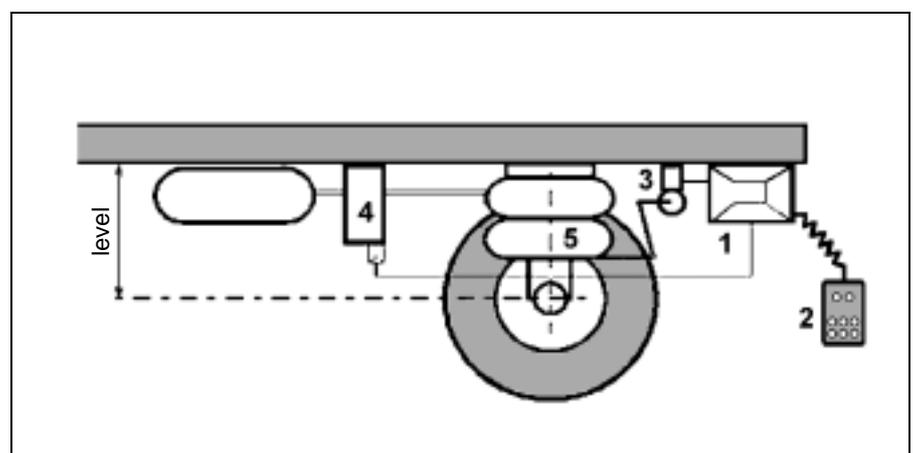
ECAS only works when the ignition is ON. Power supply for the trailer is normally provided via the ABS system. Connecting the ABS system is also necessary to ensure that ECAS receives the so-called C3 signal, i.e. information on the current speed of the vehicle.

To permit adjustment of the level of a trailer not connected to a towing vehicle, an optional facility for a storage battery may be provided for an additional power supply on the trailer.

## Example for operation in a semi-trailer without lifting axle

### Basic system:

- 1 ECU (Electronic Control Unit)
- 2 RCU (Remote Control Unit)
- 3 Height Sensor
- 4 Solenoid Valve
- 5 Air Bellows



### Description of operation

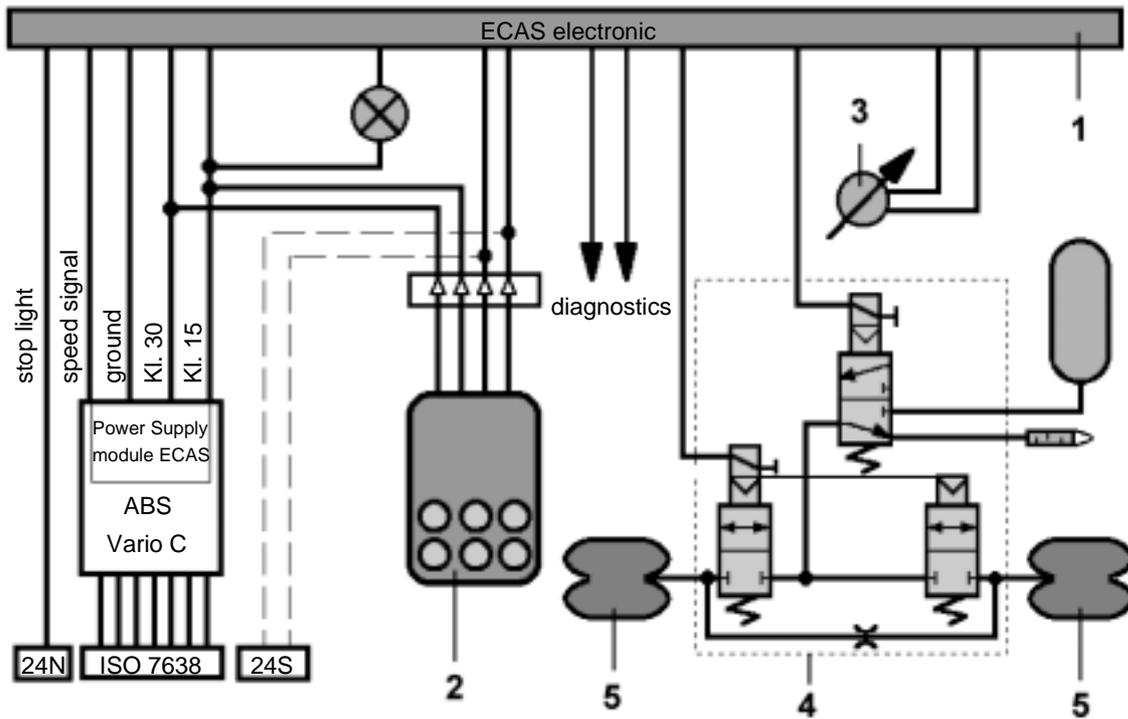
A Height Sensor (3) will continuously monitor the vehicle's height and send its readings to the ECU (1). In the event of the ECU finding that the normal level is not being maintained, a Solenoid Valve (4) is activated in such a way that, by pressurizing or venting, the level is adjusted accordingly.

Below a pre-defined speed (and when vehicle is stationary), the RCU (2) can be used to change the index level (useful for loading-ramp operation, for example).

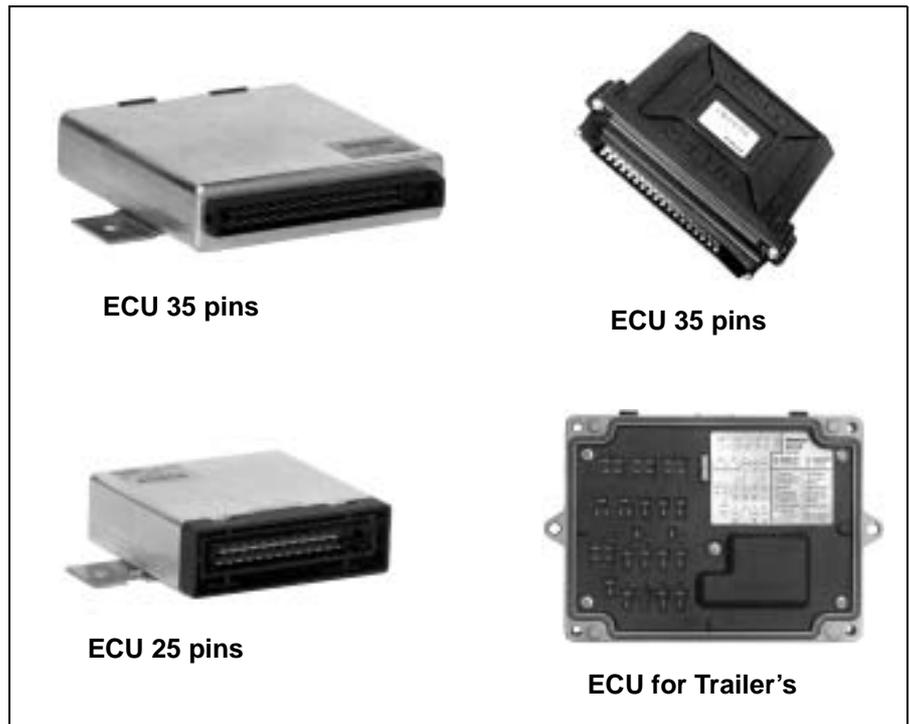
An indicator lamp (situated on the front of the trailer, and visible from the truck's cab through the rear-view mirror) is used to notify the driver that the trailer is outside its normal ride height and to inform about any faults the ECU may have discovered.

### Circuit diagram of basic system:

- 1 ECU (Electronic Control Unit)
- 2 RCU (Remote Control Unit)
- 3 Height Sensor
- 4 Solenoid Valve
- 5 Air Bellows



## ECAS-Electronic Control Unit (ECU) 446 055 . . 0



### The Electronic Control Unit (ECU)

The Electronic Control Unit is the heart of the system and is connected with the individual components on the motor vehicle by means of a 35-pole or 25-pole plug-in terminal. The ECU is located inside the driver's cab.

Together with a plug-in terminal for connecting the ECAS ECU for trailer's to the other components, the ECU is mounted on the trailer's chassis in a protective housing. This protective housing is similar to that of the ABS VARIO-C system. The ECU can be used for implementing a large number of system configurations. The plug-in terminal has a connector for every height sensor, pressure sensor and solenoid valve. Depending on the system used, parts of the terminal may not be used.

As in the ABS system, the cables are fed through glands in the lower part of the housing. To facilitate the allocation of the individual cables to the plugs, bands are taped around the cables.

### Operation

The ECU contains a microprocessor which processes digital signals only. A memory managing the data is connected

to this processor. The outlets to the solenoid valves and to the indicator lamp are switched via driver modules.

### The ECU is responsible for

- constantly monitoring the incoming signals
- converting these signals into counts
- comparing these values (actual values) to the values stored (index values)
- computing the required controlling reaction in the event of any deviation
- actuating the solenoid valves

### Furthermore, the ECU is responsible for

- managing and storing the various index values (normal levels, memory, etc.)
- data exchange with the RCU and the Diagnostic Controller
- regularly monitoring the function of all system components
- monitoring the axle loads (in systems with pressure sensors)

- plausibility testing of the signals received (for error detection)
- error recovery.

In order to ensure rapid control reaction to any changes in actual values, the microprocessor processes a fixed program in cycles of some milli-seconds, with one program cycle covering all of the above tasks.

This program cannot be modified and is fixed in a program module (ROM). However, it will use values stored in a freely programmable memory. These values, the parameters, effect the computing processes and thus the ECU's controlling reactions. They are used to communicate to the computing program the calibrating positions, the system configuration and the other preset values concerning the vehicle and functions.

## Solenoid Valves

Special solenoid valve blocks have been developed for the ECAS system. By combining several solenoid valves in one compact block, both space and installation time are kept to a minimum.

The solenoid valves are actuated by the ECU as a control element; they convert the voltage present into a pressurizing or venting process, i.e. they increase, reduce or maintain the air volume in the bellows.

In order to achieve a large throughput of air, pilot valves are used. The solenoids initially actuate those valves with a small nominal width, and their control pressure

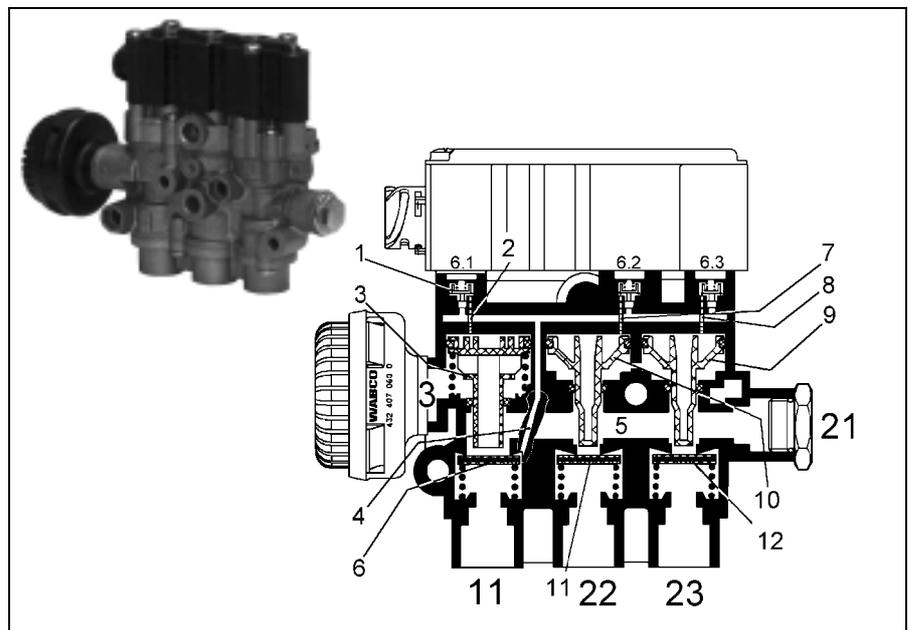
is then passed to the piston surfaces of the actual switching valves (NW 10 and NW 7 respectively).

Different types of solenoid valves are used, depending on the application: For controlling a single axle, one seat valve is sufficient whilst a complex sliding valve is required for controlling the lifting axle.

Both types of solenoid valves are based on a modular principle: Depending on the application, the same housing is used to accommodate different parts of valves and solenoids.

### ECAS Solenoid Valve 472 900 05 . 0

Valve for the axle with two height sensors



The solenoid valve shown in the illustrations below has three solenoids. One solenoid (6.1) controls a central breather valve (also known as a central 3/2 directional control valve), the others control the connection between the two air bellows (2/2 directional control valves) and the central breather valve.

This valve can be used for establishing what is known as 2-point control in which both height sensors on both sides of the axle separately control the level of both sides of the vehicle so that the body is kept horizontal even when the load is not evenly distributed.

#### Design of the Valve

Solenoid 6.1 actuates a pilot valve (1), and the actuating pressure from this valve flows through hole (2) and acts on piston valve (3) of the breather valve. The pilot valve receives its pressure via port 11 (supply) and connecting hole (4).

This drawing shows the breather valve in its venting position in which air from chamber (5) can flow to port 3 via the hole of the piston valve.

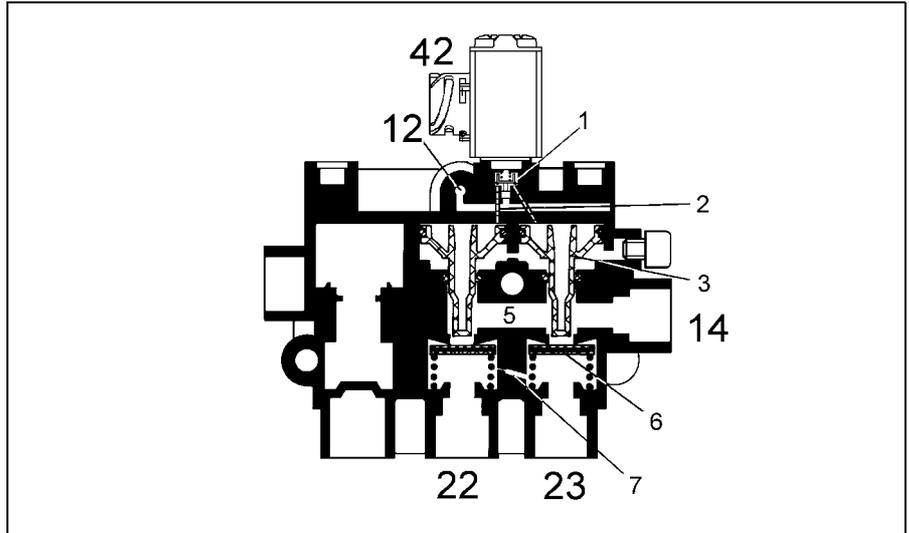
As solenoid 6.1 is energized, piston valve (3) is pushed downwards, initially causing valve plate (6) to close the hole of the piston valve. The valve plate is then pushed off its seat (hence the name 'seat valve'), and supply pressure can flow into chamber (5).

The other two valves connect the air suspension bellows with chamber (5). Depending on which solenoids (6.2 or 6.3) are energized, piston valves (9) or (10) are pressurized via holes (7) or (8), opening valve plates (11) and (12) to ports 22 and 23.

A solenoid valve for control of the other axle can be fitted to port 21.

## ECAS Solenoid Valve 472 900 02 . 0

Valve for an axle with one height sensor



This valve is similar to the valve described above but it contains fewer parts.

Since port 14 is connected to port 21 of the valve described above, no breather valve is needed and only one pilot valve (1) is used. The piston valves (3) of both air suspension bellows valves are pressurized via two connecting holes (2) so that each pressurizing or venting process is effected evenly for both bellows via chamber (5).

If the solenoid is not energized, the valves are closed, as shown in the illustration. At this time, the only connection between the bellows is the lateral choke (7), through which any difference in pressures can gradually be compensated.

The valve is connected to the air supply via port 12. This port is needed merely to permit the pilot valve to displace the piston valve.

## ECAS Solenoid Valve 472 905 1 . . 0

Sliding valve with rear axle block and lifting axle block



## ECAS Solenoid Valve 472 900 05 . 0

Valve for the bus with a kneeling function

### ECAS Remote Control Unit 446 056 0..0



By means of the RCU the driver can influence the vehicle's level within the permissible maximum limits. However, this can only be done whilst the vehicle is either stationary or has not exceeded the driving speed parameter.

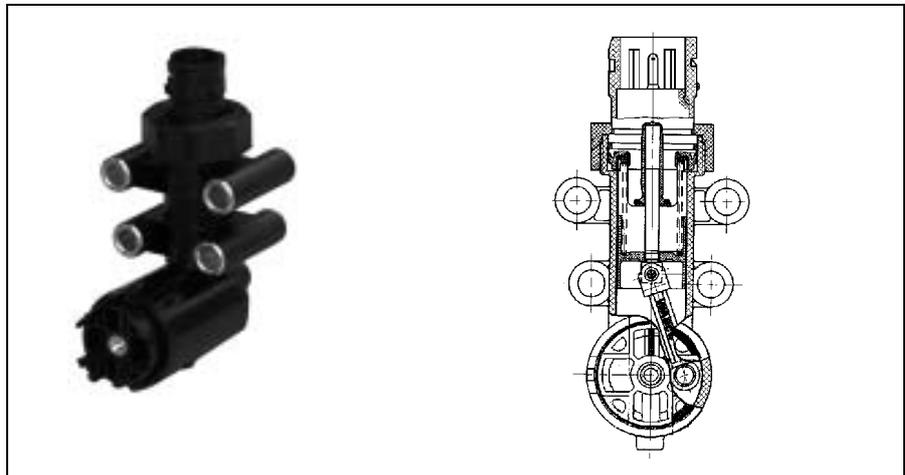
The control keys for changing the vehicle's level are accommodated in a handy housing which is connected, via a coiled cable and a socket on the vehicle, with the ECU.

There are different RCUs depending on the type of system used. The above illustration shows a unit with the largest pos-

sible number of functions. The functions of this RCU are:

- raising and lowering of the chassis
- setting normal level
- stop
- storage and actuation of two preference levels
- raising and lowering of the lifting axle, or unloading or loading the trailing axle
- switching automatic lifting axle operation on and off.

### ECAS Height Sensor 441 050 0..0



From the outside, the height sensor looks similar to WABCO's conventional levelling valve which means that it can often be fitted in the same location on the vehicle frame (the pattern of the two upper mounting bores is similar to that of the levelling valve).

The sensor housing contains a coil in which an armature is moved up and down. Via a connecting rod, the armature is connected to a cam on the lever's

shaft. The lever is connected to the vehicle axle.

As the distance between the superstructure and the axle changes, the lever is turned, causing the armature to move into or out of the coil. This changes the coil's inductance.

This inductance is being measured by the electronic control unit at short intervals and converted into a height signal.

## Pressure Sensor 441 040 00 . 0



The pressure sensor produces a voltage output which is proportional to the pressure present. The measuring range lies between 0 and 10 bar; a pressure of 16 bar must not be exceeded.

The signal voltage is sent to the ECU via a connecting plug. Furthermore, the sensor must receive a supply voltage from the ECU via a third conductor. The cable harness must be encased in a hose or similar material in such a way that the housing - which is otherwise waterproof - can "breathe".

Under no circumstances should the pressure sensor be connected to the connecting line between air suspension bellows and solenoid valve since this could result in wrong readings when pressurizing or venting is in progress.

If air suspension bellows with two threaded ports, as offered by renowned manufacturers of air suspension systems, cannot be used, a special connector must be fitted.

This connector can consist of a T-shaped pipe union, with a small pipe being welded into its pressure sensor connection protruding into the inside of the bellows, thereby sensing the "settled" bellows pressure (these fittings are available from WABCO).

A normal tee-piece can be used but only when a high raise/lowering-speed is not required. Two examples:

- One axle is sensed (drawbar-trailer with one LA). The feed pipe from bellows to solenoid should be small (nominal size  $\varnothing$  6) but the connection between bellows and sensor large.
- Two axles are sensed (3-axle semi-trailer with one LA). Use  $\varnothing$  12 pipe between the sensed bellows. Fit the pressure sensor in a tee piece next to one bellows. The line from the solenoid valve should be  $\varnothing$  9) entering the system at the other bellows.

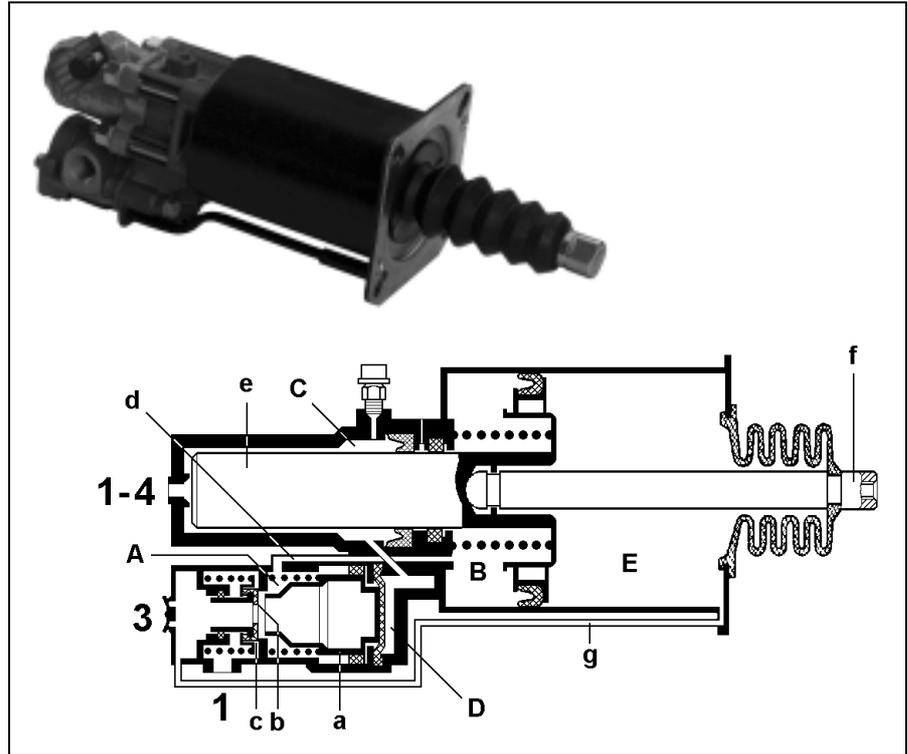


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# Clutch Servos

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**Clutch Servo**  
**970 051 ... 0**  
**Modular Series**



**Purpose:**

To reduce the force required to push down the clutch pedal and to permit sensitive and accurate actuation of the clutch.

**Design:**

The clutch servo consists of three parts:

- hydraulic slave cylinder
- control valve
- pneumatic servo cylinder.

Possible variants:

- trigger valve for transmission control
- optional feature for pressure sensors
- wear indicator.

**Operation:**

The clutch servo is connected with the air reservoir for ancillary consumers via Port 1, and with the pedal-operated hydraulic master cylinder via Port 1-4.

**a) Clutch not engaged:**

During the declutching process, the air pressurized by the pedal-operated master cylinder is forced into Chambers C and D through Port 1-4. This causes piston (a) to move to the left, closing the outlet (b) and opening the inlet (c). It thus allows the compressed air to pass from Port 1 into Chamber A and from there through the duct (d) into Chamber B. Pneumatic and hydraulic pressures force piston (e) to the right, causing the clutch to disengage through the forcing lever (f). The air pressure in Chamber A balances the hydraulic pressure in Chamber D and the control valve is in its neutral position.

ton (a) to move to the left, closing the outlet (b) and opening the inlet (c). It thus allows the compressed air to pass from Port 1 into Chamber A and from there through the duct (d) into Chamber B. Pneumatic and hydraulic pressures force piston (e) to the right, causing the clutch to disengage through the forcing lever (f). The air pressure in Chamber A balances the hydraulic pressure in Chamber D and the control valve is in its neutral position.

**b) Clutch engaged**

When the clutch is engaged once again, the oil from Chambers C and D returns to the pedal-operated master cylinder. Piston (a) returns to its original position on the right, the inlet (c) closes and the pressure in Chambers B and A is evacuated through the opening outlet (b) and Vent 3.

The hydraulic and pneumatic pressures at piston (e) fall, releasing the way back into the engaged position. Through duct (g), the pressure in Chamber E can rise or fall.

The pressure in Chamber B remains proportional to the hydraulic pressure in Chamber C at all times, thus giving the driver full control when engaging the clutch.

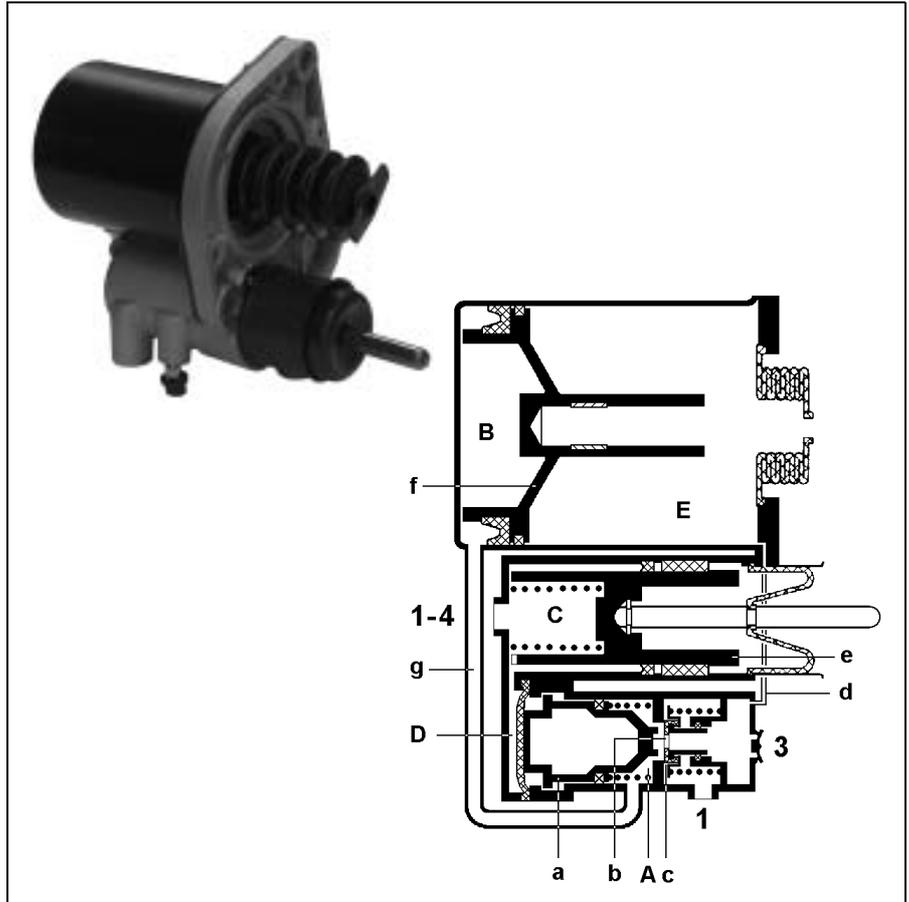
If the air pressure is insufficient, it is possible to declutch solely with the hydraulic pressure acting on piston (e). However, this requires greater force to be applied to the clutch pedal.

The design of the modular series includes automatic readjustment of the clutch, and some variants also have a mechanical wear indicator.

For vehicles with Electronic Drive Control (EAS), clutch servos from the 970 051 4.. 0 series have a pressure sensor fitted.

EAS is a system which permits pulling of and changing gear with standard aggregates without a clutch pedal having to be actuated. The driver can either change gear manually by actuating a master unit similar to EPS, or the process can be automatic through the electronic control unit.

## Clutch Servo 970 051 . . . 0 Special Design



### Purpose:

To reduce the clutch pedal effort and to provide a smooth and precise clutch operation.

### Design:

The clutch servo consists of two parts:

- a servo device: hydraulically controlled pneumatic control valve
- an actuating unit: differential cylinder under hydraulic and pneumatic pressure which transmits force to the clutch mechanism.

Different modifications are possible:

- pneumatic valve with plunger (3 way valve),
- threaded port at the pneumatic servo chamber,
- clutch wear warning device: electrical, mechanical or pneumatic,
- integral pneumatic pressure limiting device.

### Operation:

The clutch servo is connected to the auxiliary reservoir via port 1, and via port 1-4 to the pedal actuated hydraulic master cylinder.

### Clutch disengagement position:

When disengaging the clutch, the oil forced by the pedal actuated clutch master cylinder enters through port 1-4 into chambers (C) and (D). Piston (a) moves to the right, closes outlet (b), opens inlet (c) allowing the compressed air from port 1 to enter into chamber (A), and to flow through channel (g) into chamber (B).

Forced by the pneumatic pressure, piston (f) moves to the right causing the clutch to disengage by means of a push rod connected to the clutch actuating lever. The pneumatic pressure in chamber (A) balances the hydraulic force in chamber (D) closing inlet (c).

### Clutch engagement position:

When reengaging the clutch, the oil in chambers (C) and (D) is returned to the

pedal controlled clutch master cylinder. Piston (a) returns to the right, closes inlet (c), opens outlet (b) and allows the compressed air to be vented from chambers (A) and (B) to the atmosphere through port 3. The hydraulic and pneumatic pressures on pistons (e and f) decrease, allowing them to return to the left, to the clutch engagement position. The air pressure partially returning through channel (d) compensates for the vacuum in chamber (E).

At all times, the pneumatic pressure in chamber (B) remains proportional to the hydraulic pressure in chamber (C) thus giving the driver full control of the clutch engagement.

If there is insufficient compressed air, clutch disengagement is still possible with the hydraulic pressure acting on piston (e). However, this requires greater pedal effort.

The spring behind piston (e) compensates for clutch friction wear.



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# Air Braking Systems In Agricultural Vehicles

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## Brief Description Of The Different Air Braking Systems

In the single-line braking system, a single air line between the tractor and its trailer is used to fill the air reservoirs on the trailer while the vehicle is in motion, and as the trailer is braked the pressure in that line is reduced.

In the twin-line braking system, there is one line each between the tractor and its trailer, one for filling the trailer's air reservoirs and one for controlling the braking process (by reducing the pressure). The benefit of such a system is that the supply of compressed air on the trailer is also being topped up during the braking process.

In a combined single and twin-line braking system, this system can use either the principle of the single-line or the twin-line system. Towing vehicles with a single-line and a twin-line connection for the trailer thus permit both trailers with a single-line or with a twin-line braking system to be connected.

It is important to remember that the brakes of a trailer with a single-line system cannot be operated if it is used be-

hind a tractor with a twin-line braking system; the same also applies vice-versa.

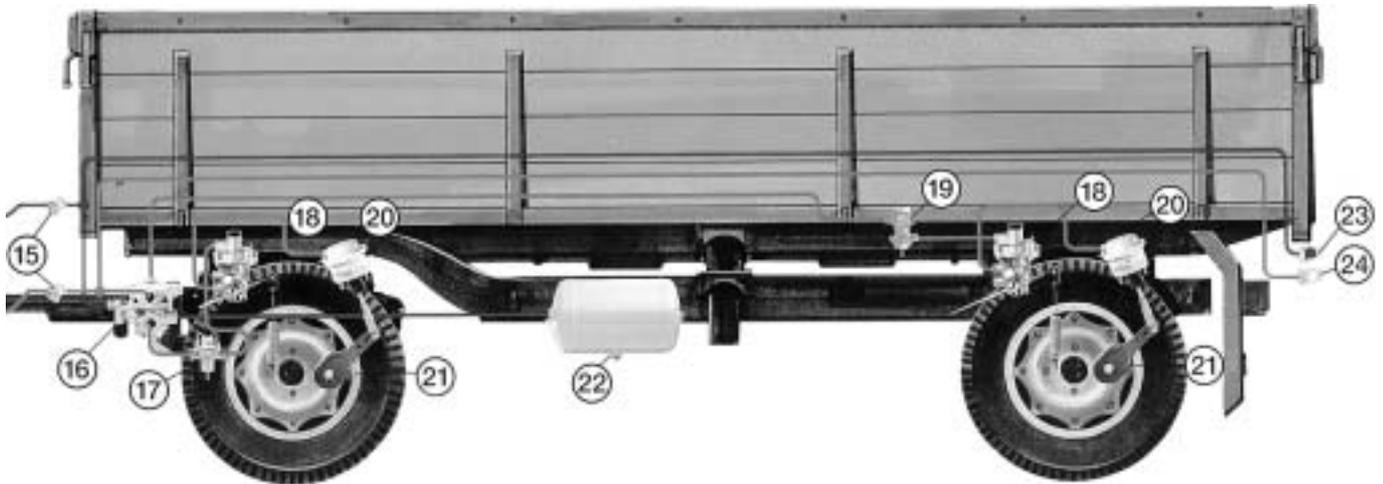
## Benefits Of A Twin-Line Air Braking System

- The operating pressure and thus the additional braking force can be sensitively graded. The same also applies to long downhill gradients.
- Because of its adjustable predominance on the relay emergency valve, the tractor-trailer combination remains stretched-out and the trailer does not run up to its tractor.
- Less wear on the tractor's brakes and thus longer life and lower maintenance cost.
- Any slight leakage does not effect the performance. The compressor always supplies sufficient compressed air for the braking system, also during the braking process.
- Unintentional disconnection of the trailer from the tractor causes the trailer to be braked automatically (breakaway brake).

- High level of safety and enhanced ride comfort. The jerking common with trailers which have had overrun brakes fitted is prevented.
- It is not possible to mismatch hose couplings due to the built-in mismatch-safeguard.
- Non-polluting because the medium, air, can be emitted directly to atmosphere.
- Easy and simple to retrofit the air braking system.

## Design of the Air Braking System

The air braking system shown in the illustration is a high pressure braking system (HPR) whose pressure level is controlled by an unloader valve (2). This supply pressure of 14 bar is limited to 7.3 bar by the pressure limiting valve (4) located downstream from the air reservoir, thus in effect achieving a normal pressure braking system (NPR). The trailer's braking system (in this illustration it is a dual line braking system) is actuated by the master cylinder (7) via an air/hydraulic dual line trailer control valve (8).



## Operation:

### Driving Position

The compressed air from the compressor (1) flows via the unloader valve (2) which automatically controls the operating pressure of the tractor's air compression system, into the air reservoir (3). The supply pressure reading is shown on the pressure gauge (5).

From the air reservoir (3), the air flows via the pressure limiting valve (4), set to 7.3 bar, to the dual line trailer control valve (8), the 3/2 way valve (6), the single line trailer control valve (9) and on to the supply hose coupling. In the trailer control valve (9), the pressure is limited to 5.3 bar which reaches the hose coupling (11) (single line).

If a dual line trailer is attached, the supply pressure of 7.3 bar flows via the hose couplings (10) to the trailer passing the line filter (15), the relay emergency valve (16) and finally the air reservoir (22).

To supply a second trailer with compressed air, two additional hose couplings (23 and 24) have been provided on the trailer. These are connected to the supply and pilot lines downstream from the relay emergency valve (16).

### Braking Position

When the brake pedals are actuated, the 3/2 way valve (6) is opened and the trailer control valve (8) receives the supply pressure of 7.3 bar.

This causes a small amount of pressure to reach the relay emergency valve (16) through the pilot line, actuating it. The trailer's air supply now flows from the air reservoir (22) through the relay emergency valve, the adapter valve (17) and the load-sensing valve (18) to the brake cylinders (20) on the front axle, and through the pressure limiting valve (19) and the load-sensing valve (18) to the brake cylinders on the rear axle.

When the brake pedal is pushed down further, pressure is built up in the hydraulic master cylinder (7) which increases the actuating pressure at the trailer control valve (8). Depending on the level of hydraulic pressure, the trailer control valve (8) also builds up the pressure in the pilot line leading to the relay emergency valve (16) and, through the load-sensing valves (18), transmitted to the brake cylinders as a ratio of the load carried.

When the hydraulic braking pressure in the tractor's braking system has been re-

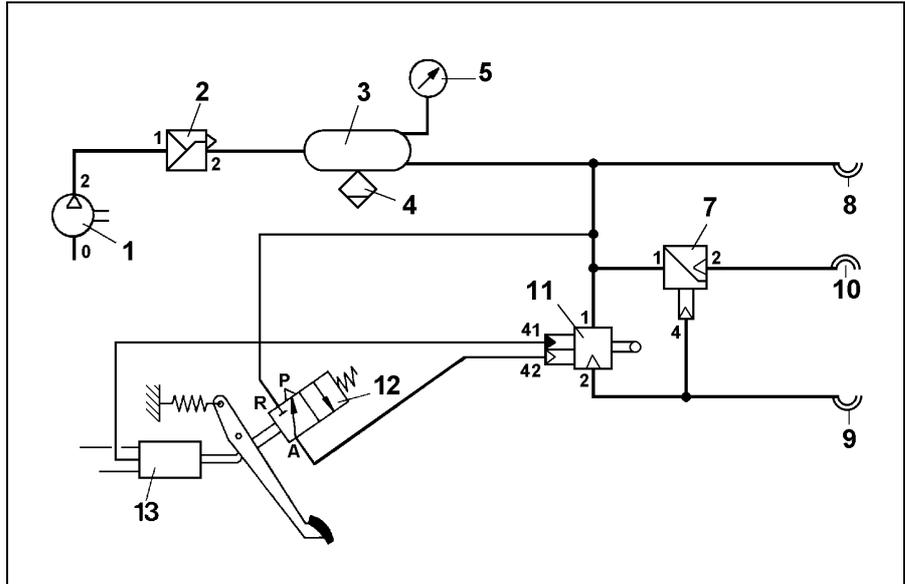
duced, the air pressure in the pilot line leading to the relay emergency valve also falls, causing the pressure in the brake chambers (20) to be reduced via the adjusting valve and the load sensing valves. The passage in the 3/2 way valve is closed once again, and the supply pressure of 5.3 bar (single line) begins to build up in the line between the trailer control valve (9) and the hose coupling (11).

### Compressed Air Generating System:

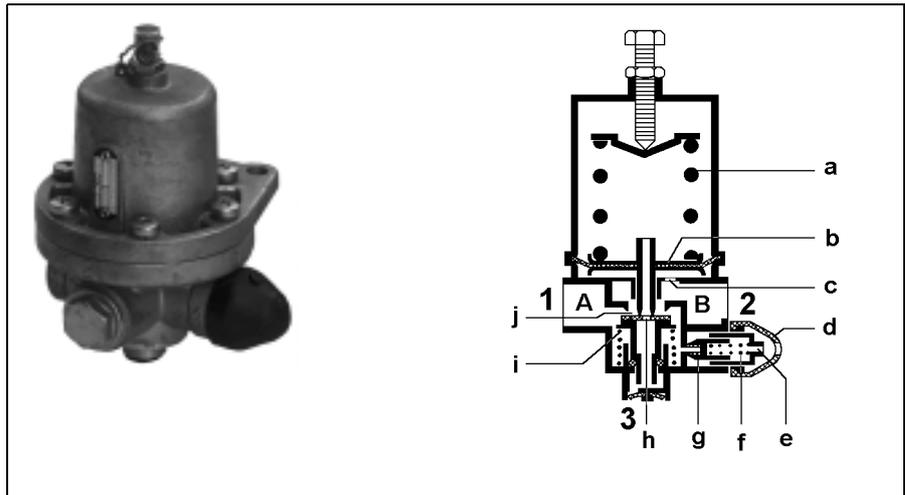
normal pressure - combined single line and dual line system hydraulically actuated

#### Legend:

- 1 Compressor
- 2 Combined Unloader
- 3 Air Reservoir 20 l
- 4 Drain Valve
- 5 Pressure Gauge
- 7 Trailer Control Valve, single line
- 8 Hose Coupling, supply line
- 9 Hose Coupling, control line
- 10 Hose Coupling, single line
- 11 Trailer Control Valve
- 12 3/2-Directional Control Valve
- 13 Master Cylinder



### Pressure Limiting Valve 973 503 . . . 0



#### Purpose:

Limitation of output pressure.

#### Operation:

Compressed air directed into chamber A through high-pressure port 1 flows through inlet (j) and chamber B to low-pressure port 2. Pressure is thereby also brought to bear via hole (c) on diaphragm piston (b), which is initially retained in its lower position by compression spring (a).

When pressure in chamber B reaches the level to which the low-pressure side is adjusted, diaphragm piston (b) overcomes the force of spring (a) and moves upwards with spring-loaded valve (i), thus closing inlet (j).

If pressure in chamber B rises above the set level, diaphragm piston (b) moves further upwards and is thereby lifted off valve (i). Excess compressed air escapes to atmosphere through hole (h) of valve (i) and exhaust 3.

If pressure starts to drop in the low-pressure line, this relieves diaphragm piston (b) of pressure so that it moves downwards and pushes valve (i) open until a sufficient quantity of compressed air has been supplied through inlet (j).

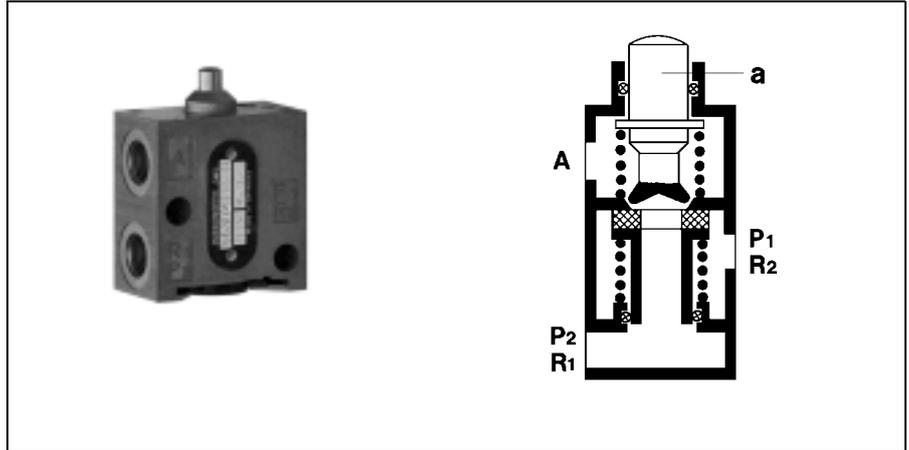
Should the pressure in the high-pressure line rise above the maximum permitted level, safety valve (g) opens against the force of compression spring (f) and al-

lows the excess compressed air to escape to atmosphere through hole (e) and dust cover (d). Pressure in the low-pressure line is not affected by this process.

The pressure existing in the low-pressure line is fully retained when the high-pressure line is evacuated.

The line at low-pressure port 2 can be evacuated only through equipment connected on that side.

## 3/2-Directional Control Valve 563 020 . . . 0



### Purpose:

To alternately control the pilot line with the supply line or the exhaust upon actuation of the brake.

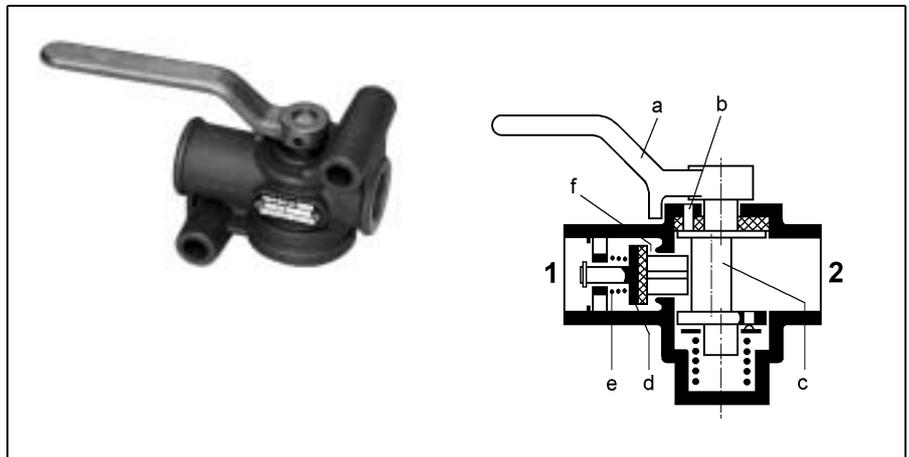
### Operation:

When the tractor's brake pedals are actuated, Piston (a) is forced to its upper position by the spring force. The compressed air from the supply line at Port P2 now reaches Port A and from there

the downstream trailer control valve. This causes a brake pressure to be output for the trailer even before the hydraulic tractor brake becomes effective.

When the tractor's brake is released, Piston (a) is pushed downward once again by the brake pedal and the passage is closed. The compressed air from the pilot line is now reduced via the opened passage to Port R2.

## Shut-Off Cock 452 002 . . . 0 and 952 002 . . . 0



### Purpose:

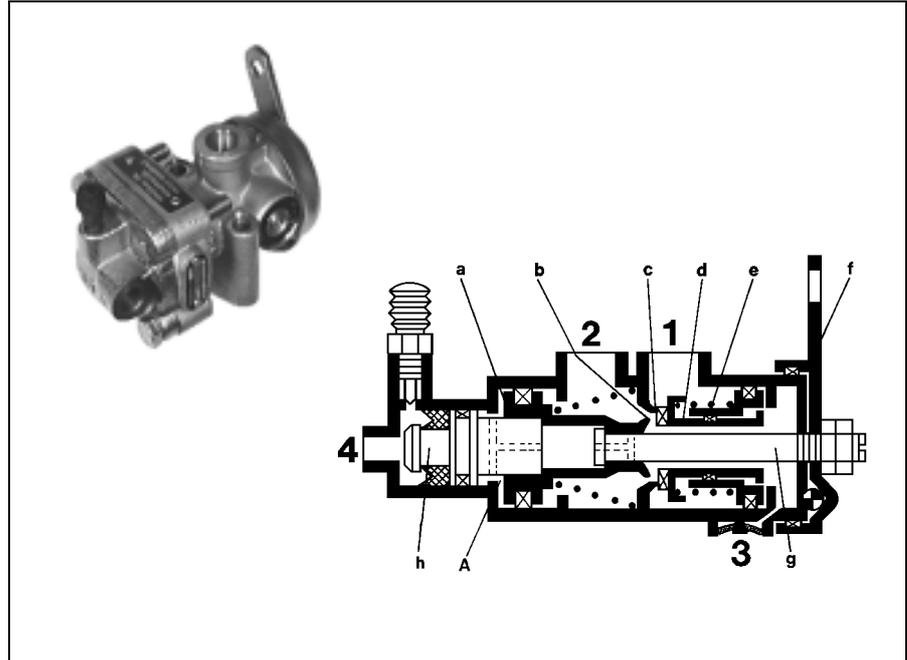
To shut off an air line and vent the downstream line.

### Operation:

When the lever (a) is parallel to the longitudinal axis of the stop cock the eccentric shaft (c) pushes valve (d) to the left against the spring (e). Air passes unrestricted from port 1 through the inlet (f) to

the line leading from port 2. If the lever (a) is turned through 90 degrees to its stop, the spring (e) moves valve (d) to the right and the inlet (f) is closed. The line leading from port 2 is vented through the exhaust drilling (b).

**Trailer Control Valve  
for dual line trailer braking  
systems  
470 015 . . . 0**



**Purpose:**

To control the dual line braking system of the trailer in connection with the trailer's hydraulic master brake cylinder or its hydraulic transmitter.

Variant 252 provides for additional pneumatic actuation, causing trailer brake pressure to be activated even before the tractor's brake becomes effective.

**Operation:**

In the release position, Compression Spring (e) pushes Valve Sleeve (d) onto Inlet (c), keeping it closed. Port 2 is connected with Exhaust 3 via Outlet (b).

When the brake pedal is depressed, the hydraulic control pressure will act on Piston (h) via Port 4, displacing that piston, together with Graduating Piston (a), to the right. Outlet (b) is closed, Inlet (c) opens and the compressed air present at Port 1 flows to the relay emergency valve via Port 2. The compressed air acting on Graduating Piston (a) moves it to the left against the hydraulic control pressure, and Inlet (c) is closed. A final position has now been reached.

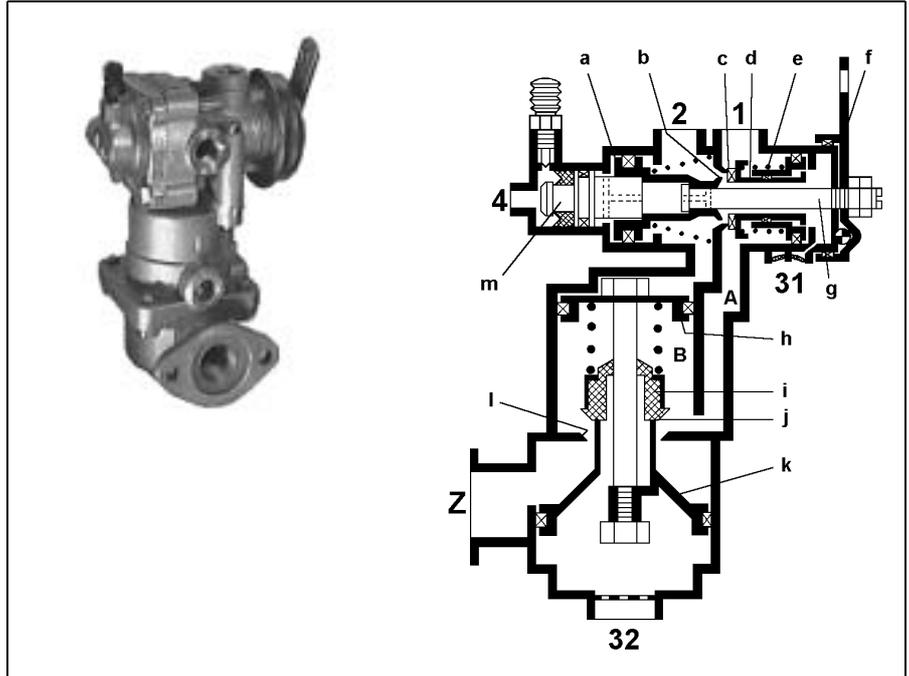
Some dual circuit Variants is also fitted with an additional pneumatic control port. This permits an upstream 3/2-way

valve to pressurize Port 42 and thus Chamber A with an actuating pressure of 7.3 bar when the brake pedal is depressed. Piston (a) closes Outlet (b), opening Inlet (c). Thus a small amount of actuating pressure reaches the relay emergency valve via Port 2 before actuating pressure builds up at Port 4.

Any increase in the hydraulic actuating pressure will also cause the pressure at Port 2 to be increased. As the brake pedal is released, Ports 4 and 42 will be depressurized, causing the pressure in Port 2 to return Graduating Piston (a) to its original position. Outlet (b) opens, and Port 2 is vented via Exhaust 3.

The Trailer Control Valve also has a Hand Brake Lever (f) which, as the hand brake is actuated, will push Piston (a) against Valve Sleeve (d), thus opening Inlet (c), causing full braking of the trailer.

**Trailer Control Valve  
for single or dual line trailer  
braking systems  
470 015 5 . . 0**



**Purpose:**

To control the single or dual line braking system of the trailer in connection with the trailer's hydraulic master brake cylinder or its hydraulic transmitter.

**Operation:**

In the valve's release position, Compression Spring (e) pushes Valve Sleeve (d) onto Inlet (c). The air supplied via Port 1 flows via Hole A into Chamber B, raising Piston (h) which takes with it Piston (k) and Valve (i). Inlet (l) is opened, permitting the air supplied to flow via Port Z into the trailer's (single) control line. When the forces of Pistons (h and k) are balanced, Inlet (l) is closed and the pressure at Port Z is limited to 5.2 bar. Port 2 is vented via Outlet (b) and Exhaust 31.

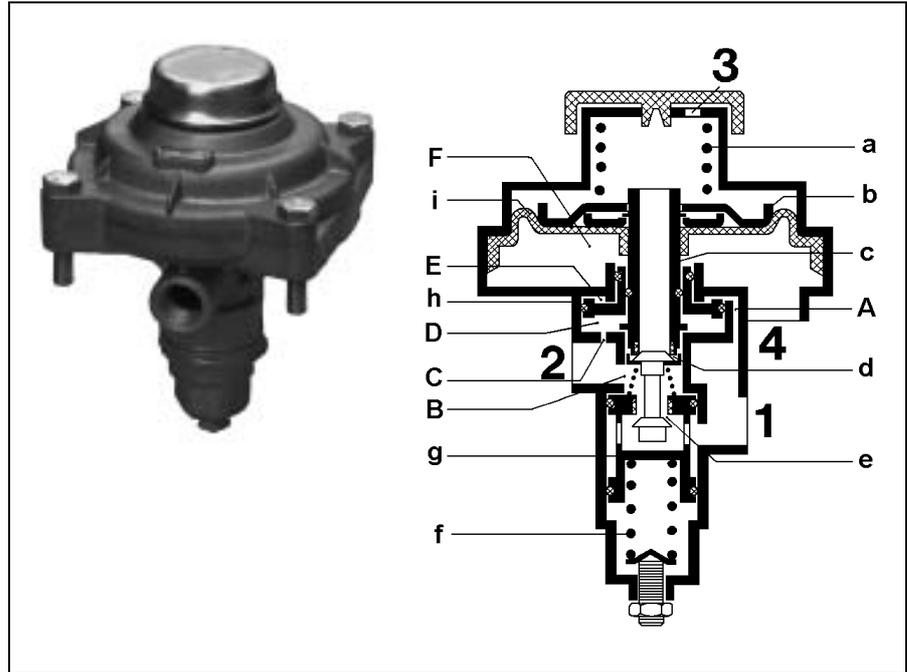
When the brake pedal is depressed, the hydraulic control pressure will act on Piston (m) via Port 4, displacing that piston, together with Graduating Piston (a), to the right. Outlet (b) is closed, Inlet (c) opens and the compressed air can now flow via Port 2 to the control line trailer's dual line braking system. The compressed air acting on Graduating Piston (a) moves it against the hydraulic control pressure, and Inlet (c) is closed. A final position has now been reached. At the same time, the pressurized Piston (h) is pushed downwards. Outlet (j) is opened,

and Port Z is partially vented via Exhaust 32. A final braking position has been reached when the force in Chamber B acting on the underside of Piston (h) is greater than the force acting on the top of Pistons (h and k). Piston (h) is raised to a point where Outlet (j) and Inlet (l) are closed.

When the brake pedal is released, Port 4 is depressurized, causing the pressure in Port 2 to return Graduating Piston (a) to its original position, opening Outlet (b). Port 2 is vented via Exhaust 31. At the same time, the pressure acting on the top of Piston (h) is reduced and the supply pressure in Chamber B pushes it to its top end position. Via opened Inlet (l), Port Z is once again pressurized up to 5.2 bar.

The Trailer Control Valve also has a Hand Brake Lever (f) which, as the hand brake is actuated, will push Piston (a) against Valve Sleeve (d), thus opening Inlet (c), causing full braking of the trailer.

**Trailer Control Valve  
with pressure control  
471 200 . . . 0**



**Purpose:**

To control the single line air braking system of the trailer in combination with the trailer control valve attached to the foot brake lever for the tractor's dual line trailer braking system and for limiting the output pressure to 5.2 bar.

**Operation:**

In the release position, Compression Spring (a) will hold Diaphragm Piston with Valve Sleeve (c) in its lower end position. Outlet (d) is closed and Inlet (e) open. The compressed air from the tractor's air reservoir flows via Port 1 to Port 2 and reaches the relay emergency valve via the hose couplings. At the same time, the compressed air flows, via Hole C, into Chamber D below Piston (h), and via Hole A into Chamber E above Piston (h). As soon as the pressure in Chamber B and in the line to the trailer has reached 5.2 bar, Valve (g) is forced downwards against the force of Compression Spring (f) until Inlet (e) is closed.

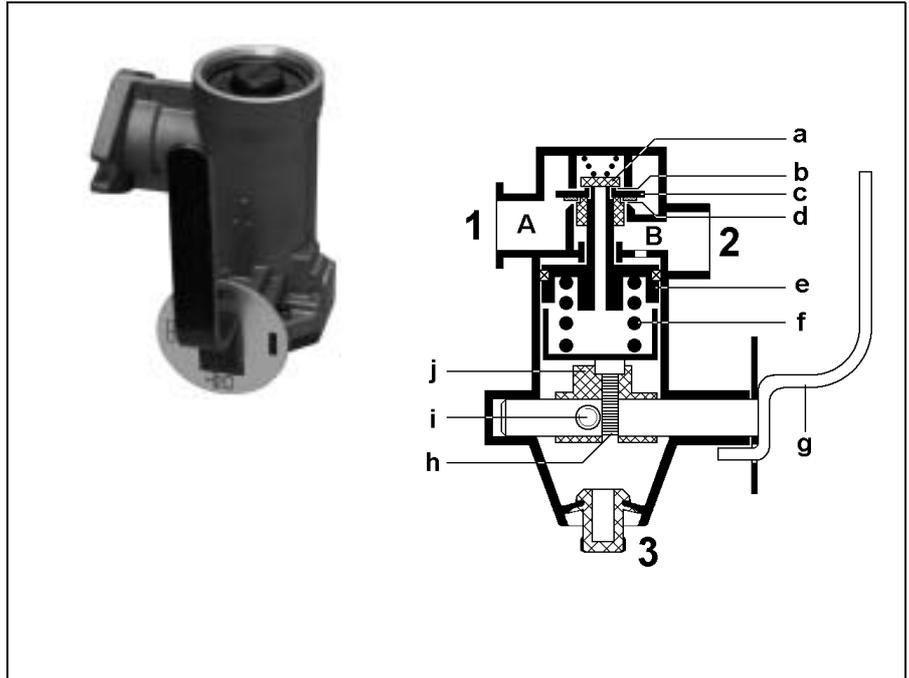
When the tractor's foot brake is actuated, the output pressure from the trailer control valve which is affixed to the foot brake lever for the dual line trailer braking system will, via Port 4, reach Chamber F where a pressure will now build up below the Cup Collar which forces Diaphragm Piston (b) with Valve Sleeve (c) upwards against the force of Compress-

ion Spring (a). Outlet (d) opens. Through Valve Spee (c) and Exhaust Hole 3, sufficient air will now be emitted to atmosphere to achieve the abrupt reduction in pressure required for advanced retardation of the trailer.

At the same time, the pressure in Chamber D will fall and Piston (h) is forced downwards by the supply pressure in Chamber E acting on its upper portion. It takes with it Valve Sleeve (c) which in turn closes Outlet (d) as it settles on the double cone valve.

As described above, the increased braking effect of the tractor causes the pressure of the trailer's control line to be further reduced whilst the advanced retardation of the trailer is maintained. When the tractor brake is released, the pressure in Chamber F is reduced once again, causing Diaphragm Piston (b) and Valve Sleeve (c) being forced downwards through the force of Compression Spring (a). Inlet (e) opens and the supply air present at Port 1 flows to the trailer's control line via Port 2.

## Load Apportioning Valve 475 604 . . . 0



### Purpose:

To control the braking forces of the trailer's brake cylinders as a ratio of the load setting.

### Operation:

When the brakes are applied, the pressure from the flanged relay emergency valve arriving at Port 1 flows into Chamber A and through the opened inlet (d) and Chamber B to Port 2 and thus to the trailer's brake cylinders. At the same time, pressure is applied to the piston (e) which is initially being held in its upper end position by the spring (f). The force of the spring (f) is dependent on the position of the lever (g) - together with the cam (j) - which is either 'empty', 'half load, or 'full load (or even '1/4 load' or '3/4 load', on some vehicles). As soon as the control pressure in the cylinders and on the piston (e) corresponding to the load setting has been reached, the piston (e), together with valve (c) and spring-loaded valve (a) will slide downwards, closing inlets (b and d). This prevents the pressure in the cylinders from rising further.

In the event of any leakages in the trailer's braking system, the drop in pressure will cause valve (a) to be raised by the piston (e). Inlet (b) opens and more compressed air is supplied accordingly.

When the tractor's brakes are released, Port 1 and Chamber A become pressure-

less. The higher pressure in Chamber B raises valve (c) and with valve (a). Inlet (d) opens and the brake cylinders are evacuated through Port 1 and the relay emergency valve. The reduction in the pressure acting on piston (e) causes that piston to be returned to its upper end position by the spring (f).

The 'release' position which a number of variants of this load apportioning valve have is used to release the brake when no trailer is attached. To achieve this, the shape of the cam (j) relaxes the spring (f) to the point where piston (e) moves downward, opening the outlet of the valve (a). The compressed air from the brake cylinders can escape to atmosphere through the axial hole in piston (e) and Vent 3.

The adjuster screw (i) is used to adjust the pressure reaching the cylinders from the load apportioning valve in the 'empty' position. When the lever of the load apportioning valve is in its 'full load' position, that screw is accessible after removing the cap in Vent 3 and permits the initial tension of the spring (f) to be adjusted. Unscrewing the screw (i) causes the pressure in the cylinders to be increased, screwing it in causes that pressure to be reduced. The pressure can be similarly adjusted for the 'half load' position. To do this, the 'release' position is selected, and the adjustment

is achieved by turning screw (h). On load apportioning valves which do not have a 'release' position, screw (h) is reached by selecting the 'empty' position and unscrewing the screw on the side of the bottom housing (this screw being found only on those variants).

When turning the screws (h or i), the load apportioning valve must always be pressureless.



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# **ETS and MTS - Electronic Door Control System For Motor Coaches**

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## Introduction

Due to more stringent safety regulations, the motor buses of urban public transport and the motor coaches of private operators in Germany have had to have safety controls fitted since the early eighties to protect their passengers and to reduce the hazard of accidents in workshops. The two major criteria which have had to be met since then are:

- features for opening and closing doors to protect both persons and objects
- features for the prevention of sudden door movements after re-pressurizing of cylinders.

Although these demands focusing on improvements in technical safety were met by the introduction of the two WABCO systems, following the pressureless and the pressure-reduced principle, it very soon turned out that - in terms of the number of appliances fitted and ease of maintenance - there was still room for further improvements.

This caused WABCO to develop an electronically controlled system which fully takes into account the following key requirements:

- safety for passengers
- reduction of the safety hazard in the workshop

- easy to use by workshop staff
- reduction of system cost
- no service or maintenance required.

The development, focusing on these demands, resulted in the Electronic Door Control System which has been produced since late 1987 and is known by the abbreviation

### \* E T S \*

The most important improvements which have been achieved are as follows:

- elimination of the limit and drum-type switches
- no more adjustment work to be done by the vehicle manufacturer or transport company
- development of a standard system accepted by all bus manufacturers in terms of their respective safety policies
- use of ETS in combination with simple, time-tested pneumatic actuations
- reduction of jamming forces.

## System Design of ETS

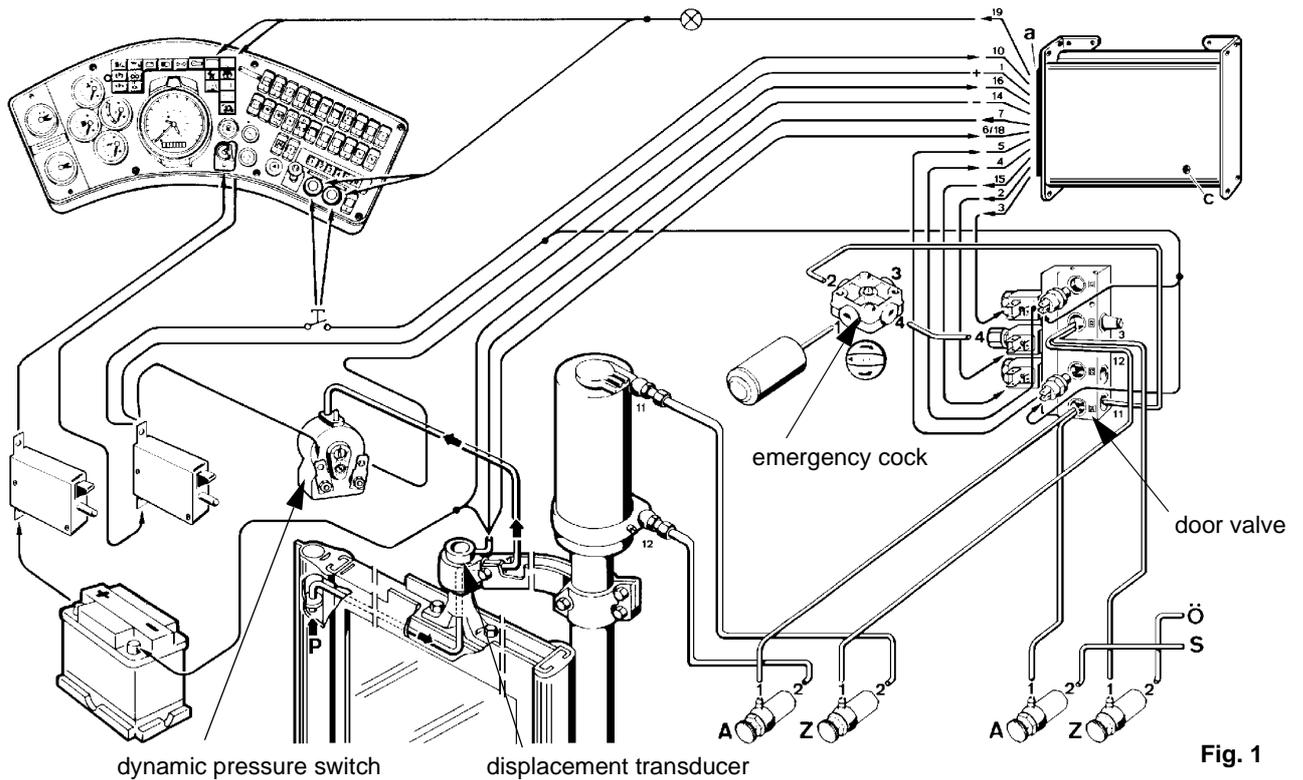


### Pneumatic Control

Compared with the pressureless and the pressure-reduced circuits, the use of ETS achieves a considerable reduction in the number of components fitted. They are replaced by a single door valve which has two key attributes:

- increasing and decreasing the pressure in the cylinder chambers (4/2 function = ordinary door operation)

- reducing door slamming after re-pressurizing the cylinders following the actuation of the emergency cock. The door continues to be 'powerless' after this process. The door leaves can be moved by hand to prevent any hazard to passengers.

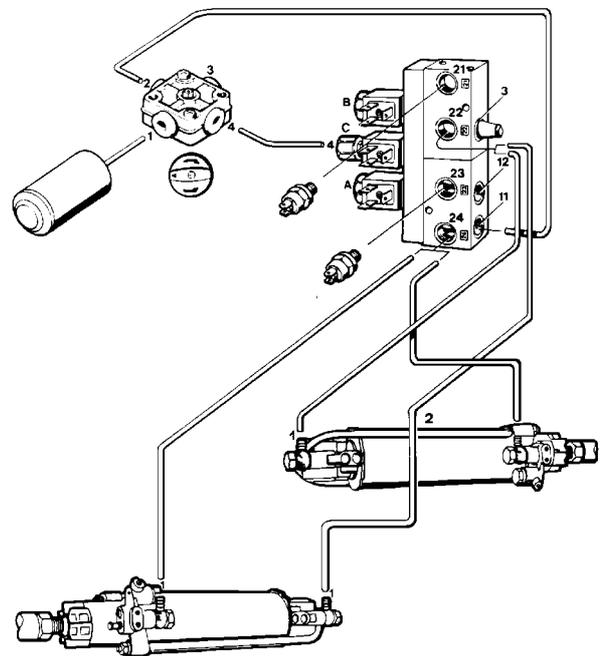


**Fig. 1**

**Fig. 1**  
Example for an ETS system with rotary drive

The layout of an ETS door control system shown above illustrates how the various door components are connected. This example shows a system with a rotary drive, i. e. the door operating cylinder is mounted directly to the rotary pillar of the door leaf.

In this example, the door is monitored by a dynamic pressure switch in addition to the displacement transducer. The dynamic pressure switch is actuated by a pressure pulse from the rubber seal of the main front edge. The ETS ECU has a separate inlet for this function.



**Fig. 2**

**Fig. 2**  
ETS system with linear door drive

This diagram shows the pneumatic connection with a linear cylinder drive. The electrical circuit is identical to that of the rotary drive.

In both types of drive, the opening and

closing speeds of the door leaves can be adjusted by means of suitable throttles or panels. For details on such adjustments, please refer to the vehicle documents provided by the vehicle manufacturer.

### ETS - ECU 446 020 . . . 0



#### Electronic Control

Electrical control is achieved by an electronic control unit with a micro-controller inside. It is available in two basic versions:

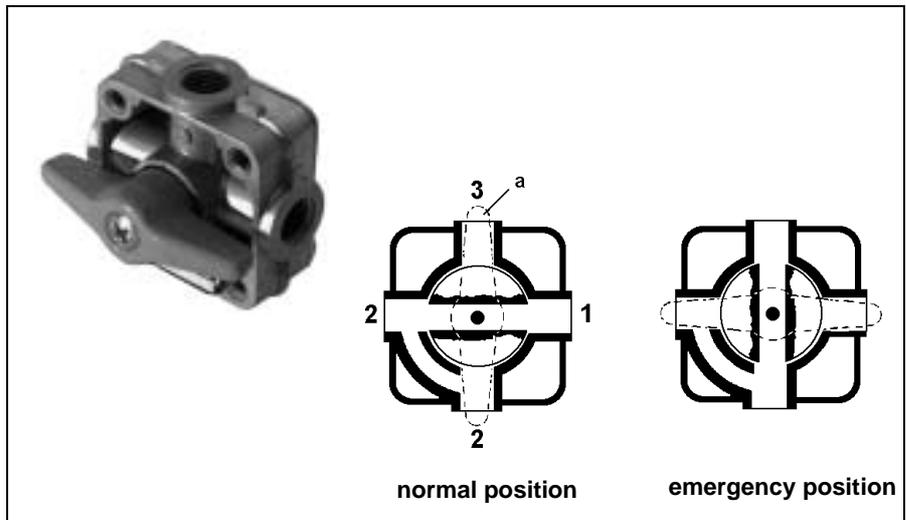
- actuation control by the driver only
- automatic system for automatic door actuation.

Both types of ECU contain identical computer programmes. Adjustment to the

various functions is made by means of a special programming process. The type of ECU can be identified by the plug-in connectors:

The ordinary control unit has a 25-pole terminal, as does the automatic control unit which, however, also has a 15-pole socket for the automatic functions and a two-way (manual-automatic) switch.

### 4/2-Way Cock (Emergency Cock) 952 003 . . . 0



#### Purpose:

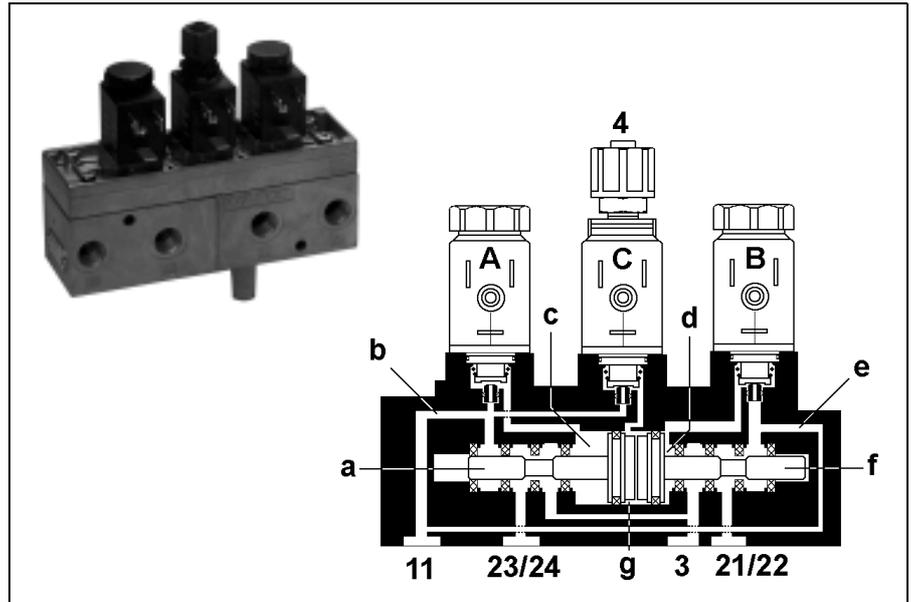
The emergency cock is needed to evacuate the air in the door operating cylinders in a hazard situation, for the purpose of repairs, or if the door operating system has failed to permit the door leaves to be moved by hand. At the same time, it actuates the door valve in such a way that when the door operating system is pressurized once more, the door operating cylinders are rendered 'powerless'. Variant 952 003 031 0 of this emergency cock has a switch for actuating a warning facility.

#### Operation:

In the normal position of the T-handle (a), compressed air from the supply line flows through Port 1, through the 4/2-way cock and on through Ports 2 into the operating lines.

By turning the handle (a) through 90° into the emergency position, the supply line is cut off and the operating lines are evacuated through Port 3.

## 4/3-Way Solenoid Valve (Door Valve) 372 060 . . . 0



### Purpose:

In normal operation, the door valve acts like a 4/2-way valve and is used to alternately pressurize the chambers of the door operating cylinders. Unlike older systems, the door of the vehicle - if it makes contact with an obstacle while opening - becomes 'powerless' which means that the door valve simultaneously pressurizes **all** chambers of the cylinder, causing the door to stop. This prevents people getting jammed, and the door leaves can be pushed by hand.

### Operation:

#### Opening And Closing of Doors

To switch the door valve to 'open', a button on the dashboard has to be pushed. This causes the ECU (outlet PIN 15) to close the electric circuit to Solenoid A of the door valve, and the armature moves upward. The compressed air in hole (b) flows into chamber (c), acting on piston (a) which is forced to the right, also pushing piston (f) into its end position on the right. In this position, Port 11 (energy supply) is connected with Port 21/22 and the compressed air flows through the door valve into the opening chamber of the door operating cylinders. Since Port 23/24 is connected with Vent 3, the doors open.

When the driver pushes the door button on the dashboard once more, the door valve is reversed into the 'close' position by energizing Solenoid B (piston (f) moves piston (a) into its left end position). The closing chambers of the door

operating cylinders are pressurized, or the opening chambers are evacuated. The doors close.

#### Jamming Protection: Reversal When Closing the Door

If a person or an object gets jammed between the main front edges of the doors, the motion of the door is impeded. Via the electronic displacement transducer (potentiometer), this impediment is detected and processed in the electronics. The door's electronics now reverse the door valve to its opening direction and the doors are opened by the reversal process. After the driver has again pushed the button on the dashboard, thus providing another switching pulse, the door cylinders are pressurized in their closing direction and the doors will close.

#### Jamming Protection: Reversal When Opening the Door

In order to comply with the guidelines for automatic doors and for doors on motor coaches actuated by the driver, the construction must be such to ensure that passengers who are located within the door area on the vehicle cannot get jammed as the doors open.

For this purpose, Solenoid C of the door valve is used, together with the electronic displacement transducers. If a person or an object is jammed by the back edge of the opening door, this impediment is perceived by the electronic displacement transducer and processed by the electronics. Solenoid C of the door valve is

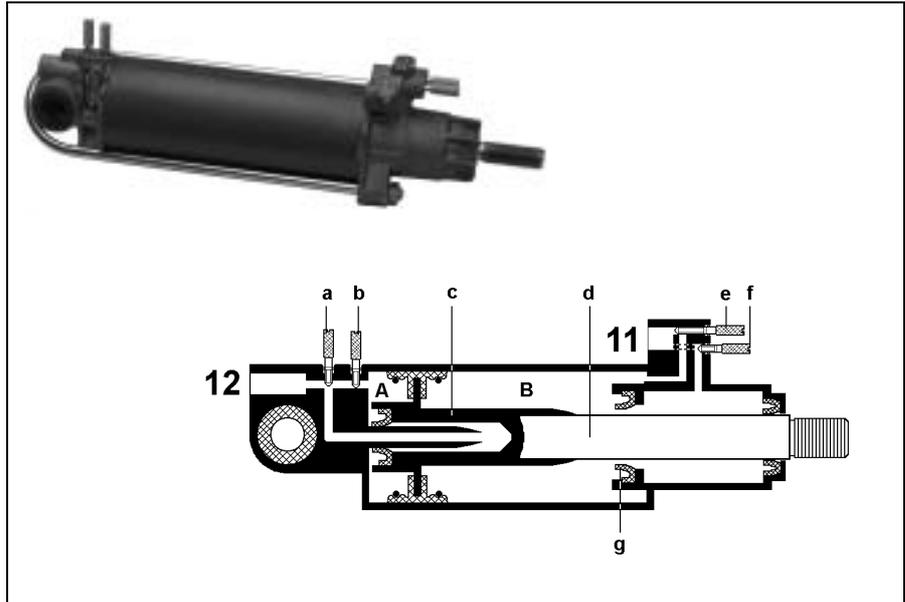
energized. The valve reverses and pressurizes chamber (g); both pistons (a and f) are in their end positions and both sides of the door operating cylinders are pressurized through Ports 21/22 and 23/24. This causes the door operating cylinders to be virtually 'powerless'. The door leaves are brought to a stop and can be moved by hand.

In this context it is important to know that - due to the difference in the surfaces of the pistons of the door operating cylinder - the door leaves slowly move to their open position when the obstacle has been removed. However, the door can now be closed at any time when the driver pushes the button on the dashboard.

#### Actuation of Emergency Cock

When the emergency cock is actuated, the door valve is actuated pneumatically through Port 4. The door operating system is evacuated via the emergency cock. The door operating cylinders are pressureless, so that the door does not move and can be opened manually. If the door is to be operated once again it is sufficient to return the emergency cock to its normal position. Through the door valve (pneumatically operated via Port 4) all chambers of the door operating cylinders are pressurized - as described under 'Jamming Protection: Reversal When Opening the Door'. The driver can then close the door again by pushing the button on the dashboard.

**Door Operating Cylinder  
for single-phase closing  
motions with damping on  
both sides**  
422 802 . . . 0



**Purpose:**

To open and close hinged and folding doors.

**Operation:**

When the door valve is actuated, the compressed air flows through Port 12 into Chamber A. The pressure building up there forces the piston (c) and the pressure bar (d) to the right, opening the hinged door. At the same time, Chamber B is evacuated through Port 11 and the upstream door valve.

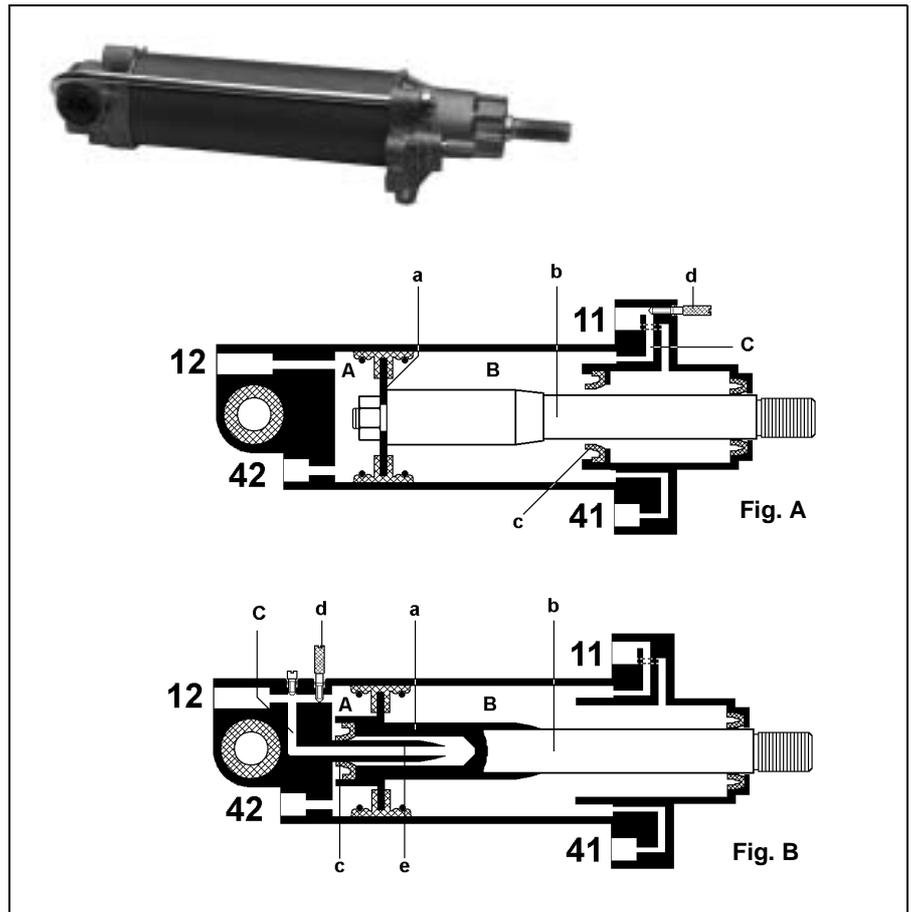
When the door valve is actuated once again, Chamber B is pressurized through Port 11 and the pressure in Chamber A is reduced through Port 12. The alternating increase in pressure on the piston (c) forces it, together with the pressure bar (d), back to the left, and the hinged door closes.

The speed of the opening and closing process can be adjusted by means of the throttle screws (a and f). To prevent heavy and noisy impact of the door as it opens or closes, the door operating cylinder has two additional throttles (b and e) which achieve a buffering effect (slowing the motion towards the end).

The compressed air displaced by the front end of the piston (c) in the door's opening motion initially escapes evenly through throttle (f) and Port 11. However, approx. 40 mm before the end of the stroke has been reached it has to pass the buffer throttle (e) since the reinforced part of the pressure bar (d) protruding into the radial seal (g) prevents a further evacuation of Chamber B through throttle (f). The buffer effect for the closing door is achieved in a similar manner. The compressed air initially escaping evenly from Chamber A through throttle (a) and Port 12 is forced past buffer throttle (b) approx. 40 mm before the end of the stroke.

The door operating cylinder has been designed in such a way that by switching over the lines from the door valve ending at Ports 11 and 12, the motions are reversed. The door will then open when the piston rod is retracted, and close when the piston rod is extended.

**Door Cylinder**  
for single phase closing motion with damping when piston rod extends or retracts  
422 808 . . . 0



**Purpose:**

To open and close slide glide and bifold doors for buses. Application is specifically for doors equipped with reverse control system.

**Operation:**

Upon activating the door valve, compressed air flows via port 12 into chamber (A). The pressure build up moves piston (a) as well as piston rod (b) to the right thereby opening the attached door. Simultaneously, chamber (B) is vented via port 11 and the subsequent solenoid door valve. At the same time, the two ports of the reverse switch, which are connected to ports 41 and 42, are pressurized or vented.

Reactivating the door valve, pressurizes chamber (B) via port 11, and chamber (A) pressure decreases via port 12. Due to the pressure differences acting upon piston (a), piston (a) and piston rod (b) move this time to the left and close the attached door. Also the reverse control switch is pressurized or vented as in the door opening process.

The door cylinder is equipped with an adjustable throttle (d) which produces considerable damping as the piston rod nears the end of its motion preventing the attached door from slamming.

**Fig. A with damping as the piston rod approaches full extension:**

During the initial phase of door opening, displaced air escapes unhindered via bore (C), however, at approximately 40 mm before the end of the stroke, the wider diameter segment of the piston rod penetrates the radial seal, preventing further venting of chamber (B) via bore (C), instead forcing air to vent through the damping throttle, which is adjustable by set screw (d).

**Fig. B with damping as the piston rod approaches full retraction:**

Approximately 40 mm before the end of the stroke, the inner bore of piston rod (b) surrounds and seals tube (e), now forcing compressed air in chamber (A) to vent through throttle (d), which is adjustable by set screw (d).

### Pressure Switch 441 014 . . . 0

The **pressure switch** is used to switch solenoid valves or indicator lamps off and on. Correspondingly, there is an on-switch and an off-switch.

The switch position is dependent upon the detail function of the facility to be

controlled. The pressure switch is not adjustable within the respective series.

For purpose and operation, please refer to Page 99.

### Displacement Transducer 446 020 4 . . 0



The **displacement transducer** (sensor) is a displacement-controlled potentiometer. In the opening process, the voltage rises from approx. **0.9 volts to approx. 14 volts** whilst in the closing process it falls from approx. **14 volts to approx. 0.9 volts**. These voltage variations are

detected and processed by the door's electronics. If the door hits an obstacle as it opens or closes, the electronics perceive this immediately and actuate the door valve **372 060 ... 0** accordingly.

## System MTS:

MTS was developed and first used in 1997 based on the experience acquired with ETS. The special feature of this system is that it can be used with any door model. Inward swivelling doors, outward swinging doors and swivel sliding doors with pneumatic or electrical drive can be combined with one another without problems!

Another innovation is also the connection to the vehicle electric unit. Here, it is possible to use a CAN data bus. Therefore, only two lines are required to control up to 5 motor coach doors.

For vehicles without a central data bus, conventional cabling can be used as an alternative. However, contrary to other systems, the lines must only be connected to the electronic control unit of the first door.

Whether you are using a CAN or conventional cabling, the individual doors must be connected via the system CAN bus

and signal processing is centralised in the control unit on the first door. This also enables you to avoid the complicated relay interconnections inherent in traditional control.

Many parameters can be set in the software, in order to easily adapt control to specific customer requirements. For all vehicle doors this data is stored on the control unit of the first door. This way, the electronic control units on all the other doors can be changed without taking the parameters into account.

Naturally, the MTS system can perform a diagnosis: diagnosis takes place via the vehicle CAN bus or via a separate "K" line, regardless of the type of connection used.

If Pneumatic doors are used, they are monitored via pressure switches and newly developed potentiometers which are fitted directly on the heel post. Due to mechanical coding, these sensors do not require any settings. Electrically driven doors can equally be monitored with

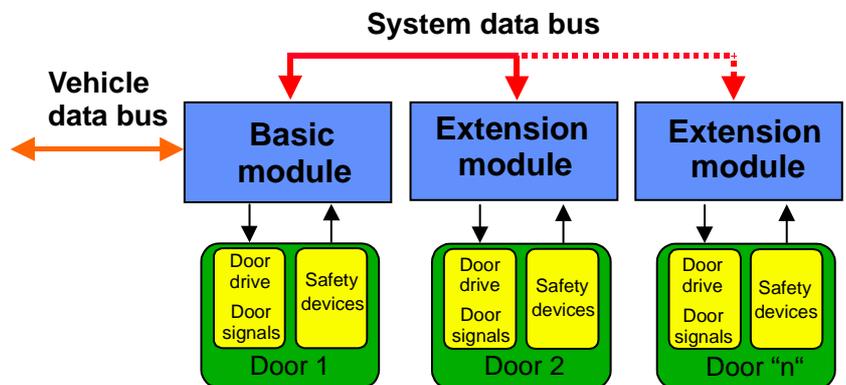
the help of these potentiometers; alternatively, pulse generators installed in the engine can be used together with an index switch.

A simple start-up program is used to balance all the tolerances while using each door for the first time. For this you only need to move the doors once to the two stop positions by pressing the workshop push buttons continuously.

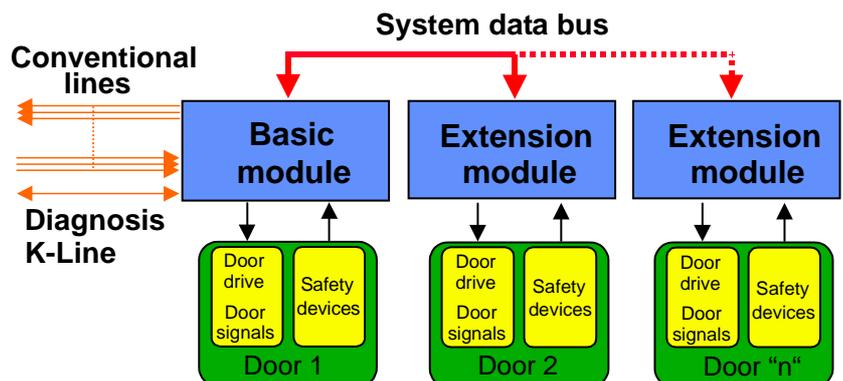
The well-proven ETS principle was developed for pneumatically driven doors. As a result, the damping mechanism integrated into the cylinders is no longer necessary. This function is now performed by the door control valve. Since it is electronically controlled, damping is possible at any moment. Apart from the cost-related advantages, this also results in much more flexible adaptability to the movement of the different doors. This also prevents misadjustments, thereby increasing operational safety.

## MTS system principle:

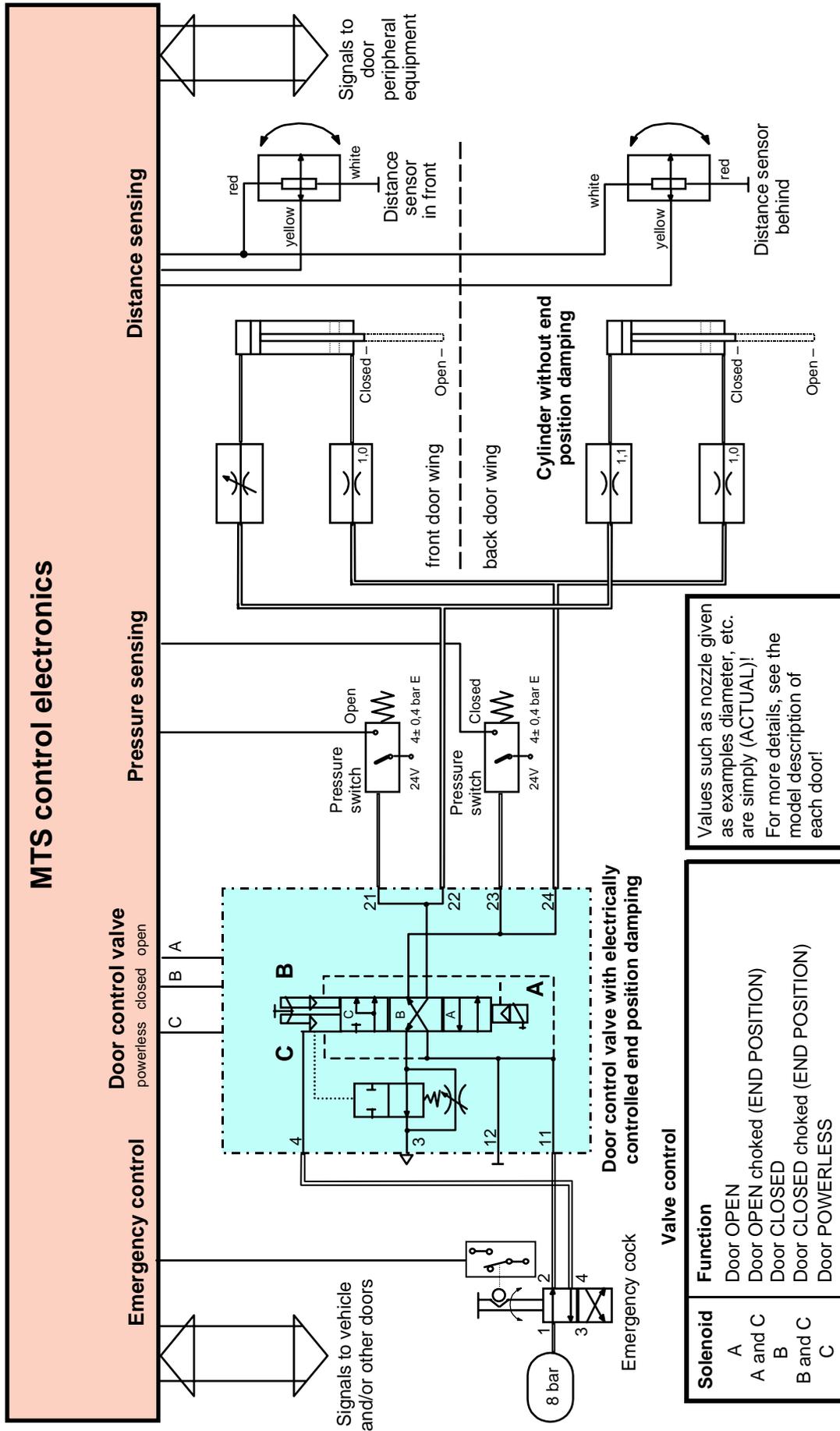
### Connection to a vehicle with CAN data bus



### Connection to a vehicle with conventional cabling



## Principle of a 2-wing pneumatic door



## MTS electronic control unit 446 190 . . . 0



MTS electronic control units have 60 PINs, divided into 5 different 3-series plugs (6, 9, 12, 15 and 18 PINs), which makes confusion impossible. Special care was taken to combine functional groups as much as possible, and to avoid double pinning.

- 9-pin: CAN data bus interfaces of the vehicle and system bus, diagnosis interface, address inputs
- 18-pin:\* power supply, drive (valves and/or engines), sensor analysis
- 15-pin: door-specific functions, e.g. workshop push button, feeling wing edge, ramp, entrance lighting, automatic functions, etc.
- 12-pin:\* used only on door 1 for conventional connection, for instance, of driver's pushbuttons, fault indication light, halt brake, red/green indicator, etc., if no CAN vehicle data bus is available.
- 6-pin:\* used only on door 1 for conventional connection (mostly) of automatic functions, for instance door release, baby carriage function, stop request output, etc. if no CAN

vehicle data bus is available. It is also possible here to connect a driver's pushbutton for door 3 (not allowed by Germany lt. § 35e of StVZO!)

There are differences on the plug side, between pneumatic door controls and electronic door controls, especially with regard to the composition of the 18-pin plug.

For MTS-P, 1 or 2 door control valves, 1 or 2 position sensors and 2 or 4 pressure switches are connected, depending on the number of door wings and/or the required function.

For MTS-E, 1 or 2 engines with 2-channel incremental indicators and the corresponding limit switches or analogue position sensors can be connected accordingly. The power supply connection and speed signal connection are identical (only on door 1).

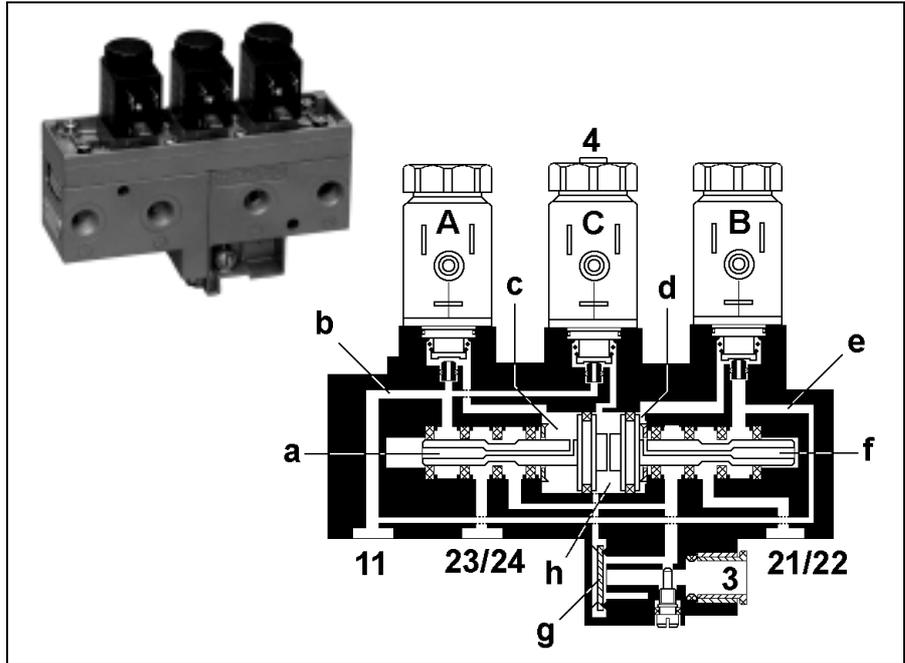
\*) For pneumatic doors, an under-equipped MTS variant ("extension module") is available for use only on door 2. The 6-pin and 12-pin plug have no function here.

The extension module can only control one door control valve

## MTS door sensor 446 190 15 . 0



**4/3 solenoid valve  
(MTS door control valve)  
472 600 . . . 0**



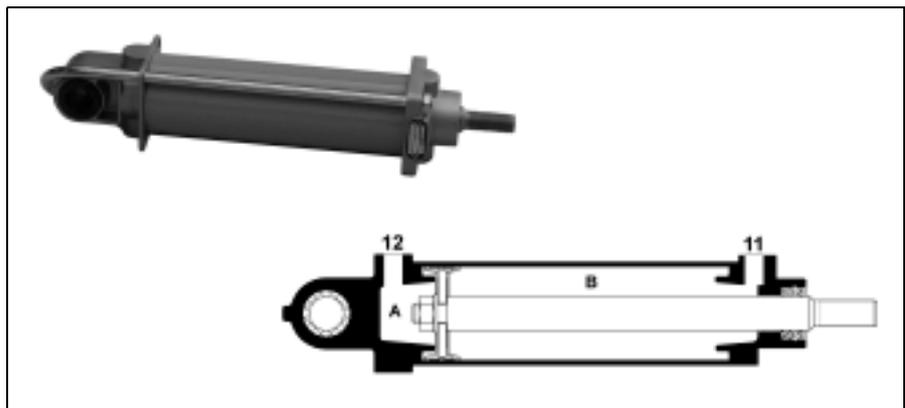
A switch-selected exhaust air throttle was added to the MTS valve in addition to the functions described on page 141 (door control valve).

Since the cylinders are controlled by the electronic control unit, they are braked before reaching the respective end positions.

Door operating cylinder exhaustion takes place without restriction if solenoids A, B, and C are idle, since pressure is exerted on the diaphragm (g).

An additional solenoid C is actuated by the electronic control unit to brake the door operating cylinder, depending on the direction of movement (one of the external solenoids A or B is activated). Air is supplied to the chamber (h), exerts pressure on the diaphragm (g) and the latter closes the passage to exhaust 3. Now, exhaust air from the door operating cylinder can only escape into the atmosphere via the adjustable throttle.

**MTS - door operating  
cylinder  
422 812 . . . 0**

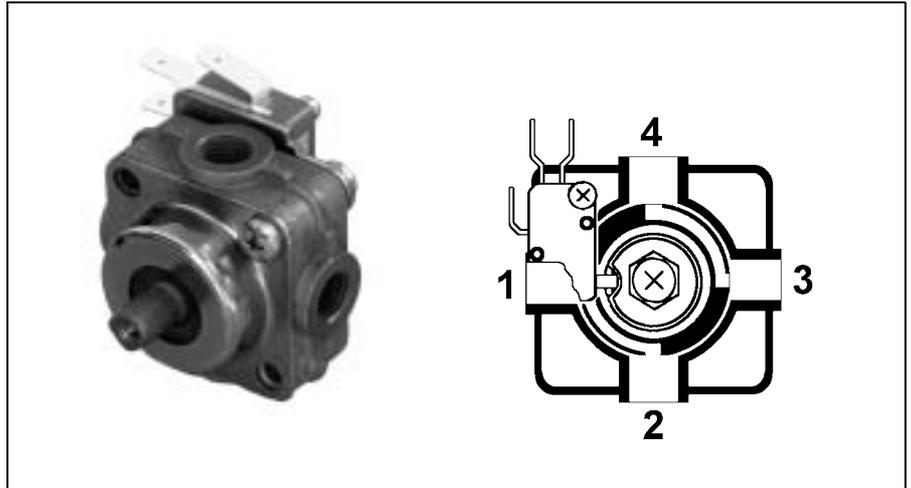


The compressed air expelled from the door control valve flows through port 12 into the cylinder and moves the piston to the right. Pressure is reduced at the same time from chamber B via port 11 and the connected door control valve.

11 and the pressure in chamber A is reduced via port 12. Due to the changing piston pressurisation, the piston moves back to the left together with the push rod and the linked door closes.

If the door control valve is activated again, chamber B is pressurized via port

## MTS emergency cock with switch 952 003 . . . 0



In normal position, air supply flows through port 1 via the cock and enters the door control valve through port 2. Port 4 is connected to exhaust (port 3).

If the emergency cock is moved 90° to the emergency position, air supply then flows to port 4 and the downstream door control valve is pneumatically switched to "powerless function" (pressure is reduced from both door operating cylinder sides).

At the same time, the electronic control unit receives an emergency cock activation signal via the integrated switch.

To prevent the door wings from moving suddenly after emergency cock reset, the door control valve always pressurises both cylinder sides simultaneously after a "powerless function".



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# Installation Of Pipes And Screw Unions

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### General Informations

The dimensions and versions of the butt-joint couplings are mainly based on DIN standards 74 313 to 74 319. Push-in couplings correspond mainly to DIN standard 2353. Butt-joint couplings are approved for use up to a pressure of 10 bar, push-in couplings up to a pressure of 100 bar.

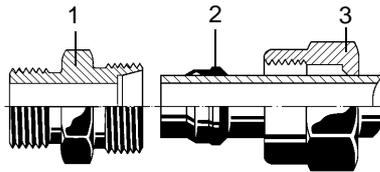
Steel couplings are used for steel and nylon pipes. The surface of adaptors and nuts are bonderized and oiled or **bright galvanized and yellow passivated**.

For copper pipes, brass couplings are available.

### General Information for Steel Pipes

Push in couplings are used for the following pipe diameters:

	Road vehicles
6 x 1	Instrumentation lines and control lines
8 x 1	Engine exhaust brake, door actuating devices, special equipment
10 x 1	Control lines
12 x 1	Brake lines and supply lines



Consisting of the following parts:

- 1 Connector with internal taper
- 2 Cutting ring
- 3 Pipe nut

Consisting of the following parts:

- 1 Connector
- 2 Sealing washer (internal)
- 3 Thrust ring
- 4 Cutting ring
- 5 Pipe nut

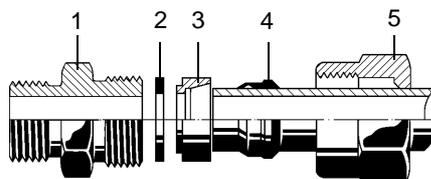
The function of the cutting ring is the same in both kinds of couplings. When the pipe nut is tightened, the cutting ring is compressed by the internal taper of the connector and cuts into the outer wall of the pipe to create a collar and form a sealed joint. The additional thrust ring in butt-joint couplings is sealed with a sealing washer normally made of fiber, or of zinc in couplings exposed to high temperatures.

#### Important:

Before fitting the coupling, check the thread for damage. Any damaged threads **must** be reworked. In order to prevent the thread seizing, it should be greased using graphite grease, Part No. 830 503 004 4 (50 gramme tube).

Butt joint couplings are used for the following pipe diameters:

	Road vehicles
15 x 1.5	Brake lines and supply lines
18 x 2	Connection from compressor to pressure regulator, supply lines



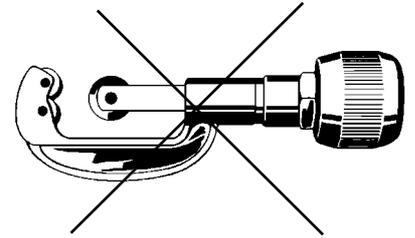
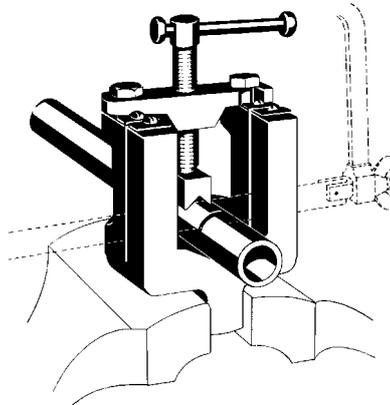
Since all sealing washers settle under load, the fittings of new vehicles or installations must be retightened after a short time. The same also applies after the replacement of devices, since new sealing washers must always be used. Before retightening unions, first loosen the pipe nut to avoid damaging the pipe.

Any non-compliance could lead to loss of pressure within the system and thus to brake failure!

## Assembly Instructions for Steel Pipe

The pipe must be cut off at right angles. A pipe saw-jig should be used.

of which would cause failure of the braking system.



After sawing the pipe, the resulting burrs and swarf must be carefully removed. In order to avoid these parts getting into the piping system after fitting, thus destroying valve seats or blocking filters, either

### Important:

**Do not use a pipe cutter !**

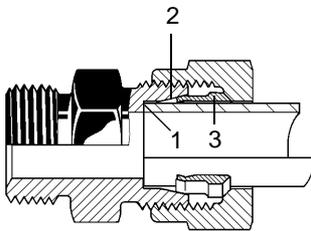
This would mean that no right angle is achieved in cutting and would result in excessive burrs, both inside and out.

### As a consequence:

the internal diameter would be reduced and the union not being tight.

## Push in Couplings

Before tightening the pipe nut



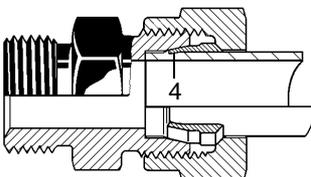
With pipes with an external diameter up to 10 mm, it is advisable to screw the connector of the coupling into the device and to assemble the pipe directly at the place of installation.

The prepared pipe end, with pipe nut and cutting ring, is pushed directly into the connector and the pipe nut is screwed on by hand until contact with the cutting ring is felt.

ing of the pipe is unnecessary. Final tightening is effected by turning the nut by about one turn. Then loosen the pipe nut and check whether the cutting ring has penetrated the outer skin of the pipe and the raised collar is visible in front of the edge. If necessary, the pipe nut must be tightened further.

It does not matter if the cutting ring can be rotated on the pipe end.

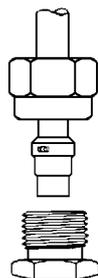
After tightening the pipe nut



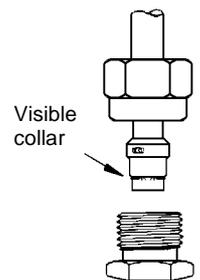
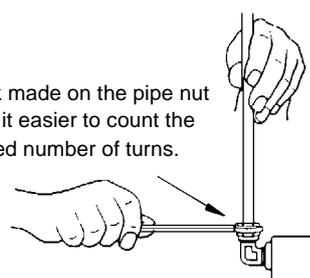
The pipe must now be pushed against the stop in the connector and the pipe nut must be tightened by about three-quarters of a turn, where by the pipe must not rotate with the nut. Since the cutting ring has now gripped the pipe, further push-

After completion of the joint, or after loosening, the pipe nut is to be tightened with a normal spanner, without applying any excessive force.

- 1 Butt end
- 3 Cutting ring
- 2 Internal taper
- 4 Visible collar



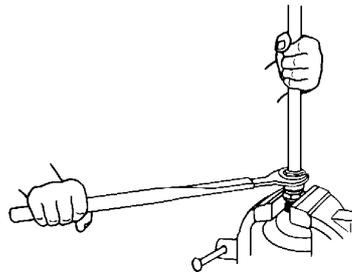
A mark made on the pipe nut makes it easier to count the specified number of turns.



### Butt joint Couplings

Pre-assembly must be carried out in a vice. The screw spanner must have a length which is approximately 15 times the width across flats. If necessary, it should be extended using a pipe.

Tighten the coupling in the vice first. Screw on pipe nut by hand up to stop at cutting ring. Press pipe with thrust ring against front side of connector. Then tighten pipe nut with a 3/4 turn (**Caution: Pipe must not turn at the same time!**). The cutting ring now grips the pipe end and further pressing is no longer necessary. Final tightening is carried out if the pipe nut is tightened again with a 3/4 turn. The ring now cuts into the pipe, visibly bunching in front of its first cutting edge.

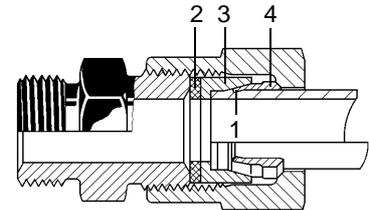


Final tightening is facilitated if the pipe nut is loosened a number of times, so that oil can find its way again between the friction surfaces.

During final assembly, please see that each pipe end the corresponding thrust ring get back to the coupling where pre-assembly has been carried out.

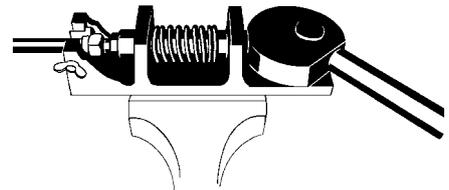
Insert thrust ring and sealing washer.

After tightening the pipe nut



- 1 Visible collar
- 2 Sealing washer
- 3 Thrust ring
- 4 Cutting ring

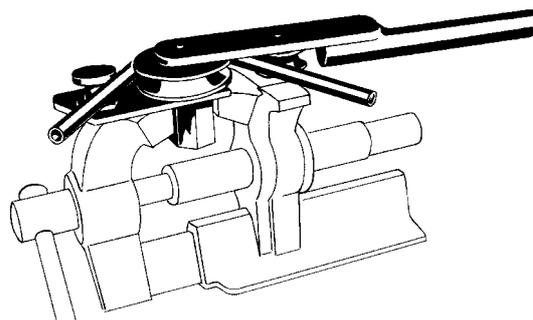
These pre-assemblies in large numbers require an enormous amount of time if they are to be produced in the way described above. In such cases, a pre-assembly unit is advisable. With it the cutting rings can be fitted quickly. The device is not tied to one work-place but can be used where desired.



### Instructions for Bending and Fitting of Pipes

Basically pipe for braking systems must never be hotworked since this will destroy the surface protection, and the scaling of the pipe can cause breakdowns.

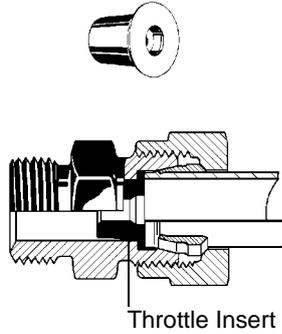
Bending of the pipe is best carried out with a commercial pipe bender.



## Assembly Instructions:

### for Throttle Inserts

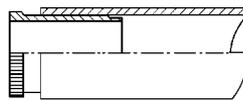
By the use of throttled inserts, the charging and exhausting time can be adjusted to the particular requirements. The throttle can be inserted into the push-in coupling, if the pipe nut has first been loosened and the pipe pulled out. Please make sure that the pipe end is shortened by the thickness of the insert's rim.



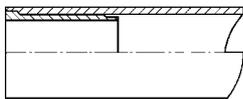
### for Copper Pipe

The assembly instructions above are intended for the use of steel pipe. If soft-annealed copper pipe (Cu soft) is to be used, sleeve inserts must be used in the pipe ends to prevent crushing the pipe when tightening the pipe nut.

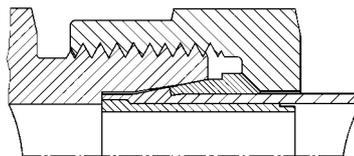
The insert is to be lightly driven into the pipe until it is flush with the pipe end. The teeth on the insert are pressed into the inner wall of the pipe so that the insert prevented from moving or failing out during assembly of the pipe.



Insert pushed in

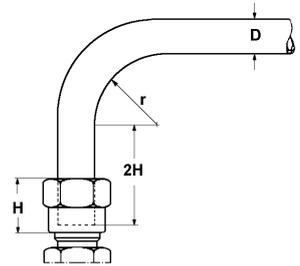


Insert driven in



Push-in coupling with sleeve insert fully assembled

The bending radius must never be less than  $2D$ . The pipe end behind the bend should, as far as possible, have a total length of at least  $2H$ .



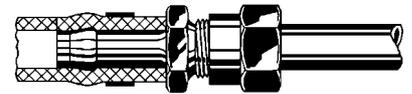
When fitting the pipes, care must be taken that they are without stresses after the pipe nuts have been tightened. This means that before tightening, the pipes fit so well that the tightening process does not serve to position them properly.

**Any non-compliance** of this could result in damage to the units, e. g. cause fissures in the cylinder base.

### Hose Couplings

Within a compressed air installation the transition from pipe to hose, or conversely from hose to pipe, will repeatedly occur if moving parts have to be connected. If the pipe ends cannot be formed into a satisfactory standard hose nozzle, a hose coupling must be used for such a joint. It is not permissible to push the hose onto a plain cut-off pipe end.

Any non-compliance can result in the hose slipping off the pipe when pressurized. This would result in a sudden failure of the braking system.



Cut off hose at right-angles and push onto the hose nozzle as far as the stop. The hose must be secured with a hose clamp.

The tools illustrated in the comments on steel pipes are available from ERMETO ARMATUREN GMBH, D-33652 Bielefeld, Germany.

### General Information on Nylon Pipes

#### Use and Installation in Automotive Vehicles

The physical and mechanical properties of nylon pipe are very different from those of steel pipe.

Extensive tests and sample installations in motor vehicles using various grades of nylon have shown that because of the special properties of the material, flexible nylon pipe of black polyamide 11 are best suited for pneumatic braking systems and associated equipment.

#### Properties

##### Material

Black polyamide 11, flexible, resistant to heat and light, even to intense ultra-violet radiation.

##### Physical Properties

Density at +20°C	1.04 g/cm <sup>3</sup>
Moisture absorption at +20° C (between 30 and 100% relative air humidity)	0.5 to 1.9%
Specific heat	2.44 J/gK
Thermal conductivity	1.05 kJ/m.h.K.
Linear coefficient of expansion between -20° C and +100° C	15 x 10 <sup>-5</sup> (1/°C)
Melting point	+186°C

##### Mechanical Properties

tensile strength	4800 N/cm <sup>2</sup>
Elongation at rupture at 20°C	250%
Elastic elongation	3.7%

Pipe Dimensions	min. Bursting Pressure in bar	max. Working Pressure at 20°C in bar
6 x 1	81	27
8 x 1	57	19
10 x 1	45	15
12 x 1,5	57	19
15 x 1,5	45	15
18 x 2	51	17

#### Permissible Temperatures

In normal vehicle operation, temperatures of - 40 °C to + 60 °C are permissible.

The indicated temperature of + 60 °C during continuous loading for the flexible grade was selected so that no changes in the properties of the material occur. At temperatures over + 60 °C the softening agent contained in this material can slowly disappear and the material assumes the properties of the semi-rigid grade.

(Constant temperature loading capacity of the semi-rigid grade + 100 °C).

The physical properties of the semi-rigid and flexible pipes are the same. The values for mechanical properties such as tensile strength, elastic elongation and working pressures are higher in the case of semi-rigid pipe. By reason of their greater mechanical resistance to deformation (bending), semi-rigid pipes are more difficult to lay than flexible ones.

Because of the limited temperature loading capacity of polyamide 11, it is advisable not to use nylon pipe in the vicinity of the engine or exhaust system. Particular care should be taken when welding to ensure that the pipes are not damaged, and if necessary they should first be dismantled.

If a sprayed vehicle is dried in a braking chamber or using radiant heaters, the unpressurised pipework must not be subjected to temperatures up to 130 °C for longer than 60 minutes.

In order to avoid damage to nylon pipes when welding, a plate should be fitted on the vehicle:

This vehicle is equipped with

**WABCO Tecalan nylon pipes**

Caution during welding operations.

Permissible exposure to heat of unpressurised lines:  
Not more than 130°C for 60 minutes.

**WABCO**

Available in German only.  
Part Number 899 144 050 4

## Chemical Resistance

Polyamide 11 is resistant to all media used in the motor vehicle such as petroleum products, oils and greases. The tubes are also resistant to alkalis, unchlorinated solvents, organic and inorganic acids and diluted oxidising agents. **(The use of cleaning agents containing chlorine should be avoided).** Advice on resistance to chemicals other than those indicated can be given on request.

## Change in Length

When installing nylon pipes particular attention should be paid to their change in length at different temperatures. The change in length of the pipe is approximately 13 times that for a steel pipe.

The coefficients of expansion are:

For steel pipes  $1.15 \times 10^{-5}$  per °C

For nylon pipes  $15 \times 10^{-5}$  per °C

This indicates a change of length per metre of 1.5 mm for every 10 °C difference in temperature. This change in length must not be restricted by the fittings holding the pipe.

To fasten the pipes in position, plastic-lined pipe clamps or clamps or holders made entirely of plastic should be used. It should be possible for the pipe to move easily in the fastenings, so that temperature induced changes in length can be distributed uniformly over the entire length of the pipe. The pipe should be clamped at approximately 50 cm intervals.

## Couplings

The range of coupling from Wabco used in vehicles can also be used for nylon pipes. Clamping rings represent similarly effective unions for pipes. To ensure good seal and tight fit of the couplings, sleeve inserts should be used for all assemblies with cutting rings and thrust rings. The sleeves should not be forced or driven in, as otherwise the pipes expand and the cutting rings can no longer be pushed on.

The couplings are made push-in couplings and buttjoint couplings.

The function of the cutting ring is the same in both kinds of union.

When the pipe nut is tightened, the cutting ring is compressed by the internal taper of the connector and cuts into the outer wall of the pipe - to create a collar and form a sealed joint. The pipe sealed by the firm fit of the cutting ring on the internal taper. The additional thrust ring in butt-joint couplings is sealed with a sealing washer, which normally consists of fiber.

Before fitting male couplings, the threads of the connecting pieces should be checked for damage. Damaged threads must be rectified. In order to prevent the thread seizing it is advisable to smear it with graphite grease before screwing in. The seal can be made with fiber or aluminium sealing rings or with thrust rings and O-rings. Do not use hemp or liquid jointing compounds.

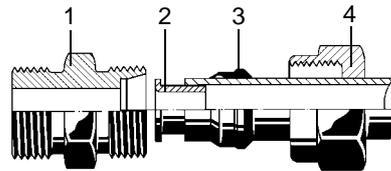
Since all sealing washers settle under load, the couplings of new vehicles or installations must be retightened after a short time. The same also applies after the replacement of devices, since new sealing washers must always be used. Before retightening fittings first loosen the pipe nut to avoid damaging the pipe.

When assembling the coupling it is important that the end of the pipe is trimmed at right angles and inserted into the coupling as far as the stop. To trim the pipe properly at right angles, use can be made of cutting devices which can be obtained for pipes with an external diameter of up to 22 mm.

### Assembly Instructions on Nylon Pipes

Push-in couplings used for the following pipe diameters:

6 x 1	As instrumentation lines
8 x 1	As auxiliary systems, e.g., air suspensions
10 x 1	As control lines with limited volumetric throughput
12 x 1.5	As control lines with larger volumetric throughput, as general lines within a brake system or as lines to the brake actuator.

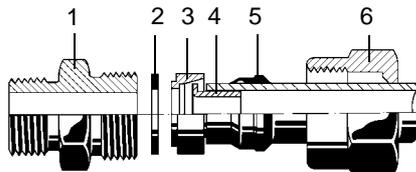


Consisting of the following parts:

- 1 Connector with internal taper
- 2 Sleeve insert
- 3 Cutting ring
- 4 Pipe nut

**Butt-joint couplings are used for the following pipe diameters:**

15 x 1.5	Lines for general supply and to braking cylinders in braking systems.
18 x 2	Supply line between air reservoir and relay valve for high air flow.



Consisting of the following parts:

- 1 Connector
- 2 Sealing washer
- 3 Thrust ring
- 4 Sleeve insert
- 5 Cutting ring
- 6 Pipe nut

### Push-in Couplings

For pipes with an external diameter of up to 10 mm, it is advisable to screw the thread of the coupling into the device and to assemble the pipes directly at the place of installation.

The prepared pipe end, with insert, pipe nut and cutting ring, is pushed directly into the connector and the pipe nut is screwed up by hand until contact with the cutting ring is felt. (Figure see page 153)

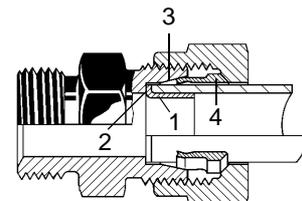
The pipe must now be pushed against the stop in the connector and the pipe nut must be tightened according to the torque table below. The pipe must not rotate with the nut.

### Table of permissible tightening torques

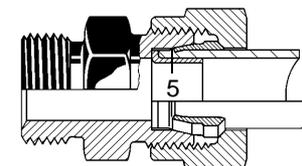
Pipe dimensions	Tightening torque	Loosening forces at
6 x 1	13 to 14 Nm	13 Nm = 460 N
8 x 1	15 to 18 Nm	15 Nm = 580 N
10 x 1	20 to 30 Nm	20 Nm = 870 N
12 x 1.5	25 to 35 Nm	30 Nm = 1200 N

If the indicated torques are not achieved, the force required for loosening is reduced, and if they are exceeded the sleeve insert will be deformed.

Before tightening the pipe nut



After tightening the pipe nut



- 1 Sleeve insert
- 2 Butt end
- 3 Internal taper
- 4 Cutting ring
- 5 Visible collar

The following method can be used to keep as close as possible to the correct tightening torques when they cannot be accurately measured:

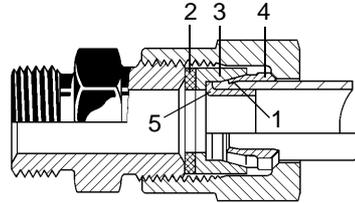
Tighten the pipe nut of the coupling fingertight and then 1½ to 1¾ turns with a spanner. It is necessary for the thread to be in good condition.

Then loosen the pipe nut and check whether the cutting ring has penetrated the outer skin of the pipe and the raised collar is visible in front of the edge.

### Butt-joint Couplings

Butt-joint couplings are assembled as described under push-in couplings. An additional thrust ring and sealing washer, however, must be used.

After tightening the pipe nut



- 1 Visible collar
- 2 Sealing washer
- 3 Thrust ring
- 4 Cutting ring
- 5 Sleeve insert

### Table of permissible tightening torques:

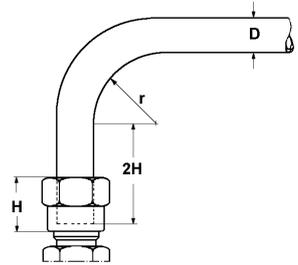
Pipe dimensions	Tightening torques	Loosening forces at
15 x 1.5	30 to 45 Nm	30 Nm = 2100 N
18 x 2	40 to 60 Nm	40 Nm = 2450 N

### Bending of Nylon Pipes

The pipe can be bent cold, keeping to the bending radi indicated below. Since,

however, it has a tendency to straighten, it should be fastened before and after each bend.

To avoid kinking, the minimum bending radi shown in the following table must be adhered to. .



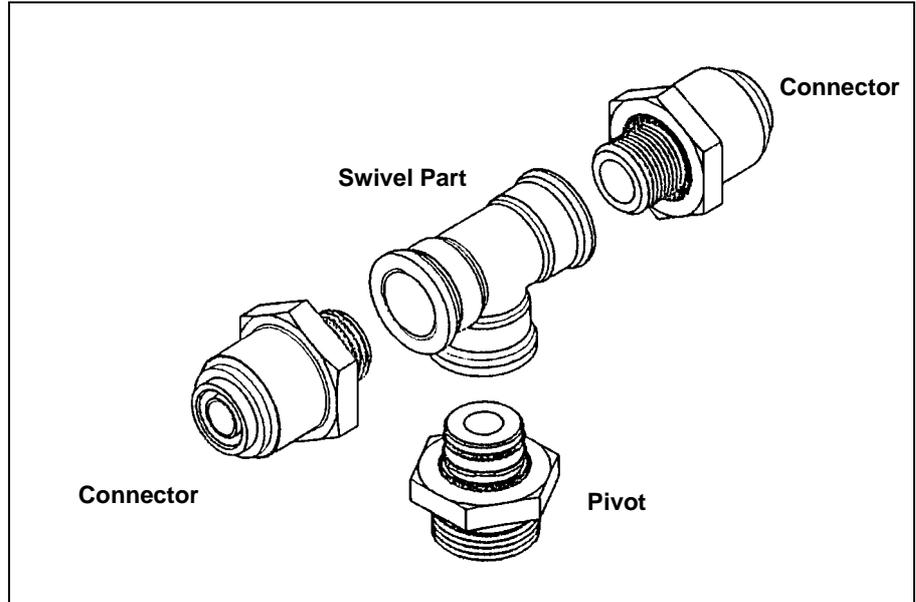
Dimensions of Pipe	min. Bending Radius r
6 x 1	30 mm
8 x 1	40 mm
10 x 1	60 mm
12 x 1.5	60 mm
15 x 1.5	90 mm
18 x 2	110 mm

### Technical Inspection of the Braking System

Inspecting authorities have given their approval in principle to the use of nylon pipe for pneumatic lines in vehicles as an alternative to the steel pipe and brake hose previously used. This approval is subject to the connection that suitable material is used for this purpose, and that the installation instructions applicable to nylon piping are complied with.

By marking their nylon pipe with the inscription „WABCO-TECALAN“, WABCO provide a guarantee that the material is suitable in accordance with terms of delivery. Correct installation of the nylon piping can be checked at the time of final inspection of the vehicle using the installation instructions mentioned above.

### WABCO Quick Connecting Fitting System for Air Braking Systems



#### General Comments

##### The connecting elements offer the following benefits:

- A high degree of leakage protection: Cascade dynamic sealing
- No corrosion since the individual components are made of brass or stainless steel.
- Quick assembly since no time-consuming fitting of sleeves, fastening of union nuts and reworking in the case of leakages is needed.
- The seal against the pipe is effected by means of a special seal located in front of the clamping element which means that the clamping element cannot damage the sealing area on the plastic pipe. The seal prevents both air getting out and dirt getting in.
- The threaded screw-in portions have an integrated seal suitable for threaded connections to DIN 3852 and for connections the type of VOSS plug-in unions.
- The throughput resistance is similar to that of the cutting-ring coupling.
- Operating temperature range -45°C to +100°C (peak +125°C).
- Integral Air Passage (Sunnest inner supporting ring wall thickness) for better and quicker brake response.

#### Applications

The quick connection fitting system is suitable for all air lines in vehicles using plastic pipes.

Any type of plastic pipe can be used:

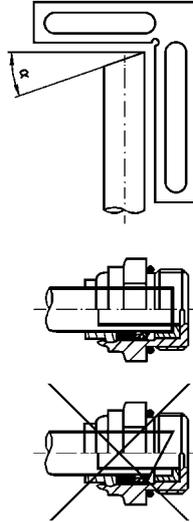
WABCO Part number	External-Ø x wall thickness	Operating pressure at 20°C in bar
828 251 908 6	6 x 1	27
828 251 907 6	8 x 1	19
828 251 906 6	10 x 1	15
828 251 905 6	12 x 1.5	19
828 251 904 6	15 x 1.5	15
828 251 903 6	18 x 2	17

## Assembly Instructions:

### Tube in a Connector

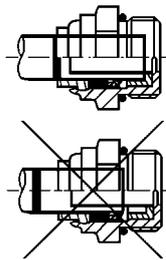
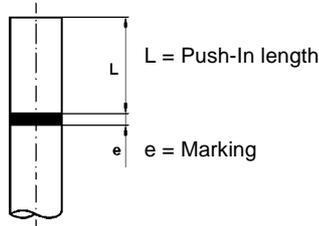
All Connectors are stamped with tube dimension, and a batch number.

The pipes must be cut at right angle. A maximum deviation of 5° is permissible..



The pipe must be pushed fully home into the push-in connector. No tool is needed. Whilst pushing in the pipe, turn it slightly.

It is advisable to mark the length pushed in to be able to check it later..



The push-in lengths and the forces required for pushing the pipe into the the push-in connectors are shown in the table below.

### Push-In lengths:

External pipe-Ø x wall thickness	Push-In length in mm (± 0,5)	Push-In forces in N
6 x 1	20	< 100
8 x 1	21	< 120
10 x 1	25	< 120
10 x 1.25	25	< 120
10 x 1.5	25	< 120
12 x 1.5	25	< 150
15 x 1.5	27	< 150
15 x 2	27	< 150
16 x 2	27	< 180
18 x 2	28	< 200

After inserting the pipe, check the clamp by applying a pulling force of at least 20 to 50 N.

### Tightening torques

Thread	Tightening torques
M 10 x 1	16 - 20 Nm
M 12 x 1.5	22 - 26 Nm
M 14 x 1.5	26 - 30 Nm
M 16 x 1.5	32 - 38 Nm
M 22 x 1.5	36 - 44 Nm

### General Comments

For reasons of safety, the connection cannot be severed once the pipe has been pushed in.

If the unit is to be exchanged, the connection must be unscrewed from the unit. The connection will turn on the pipe in the process. In the event of the sealing ring between the unit and the connection joint being damaged, it must be replaced.

For elbows and tees fixed to the unit by means of a counter-nut, the same O-rings and compression rings are used as for the cutting-ring couplings.

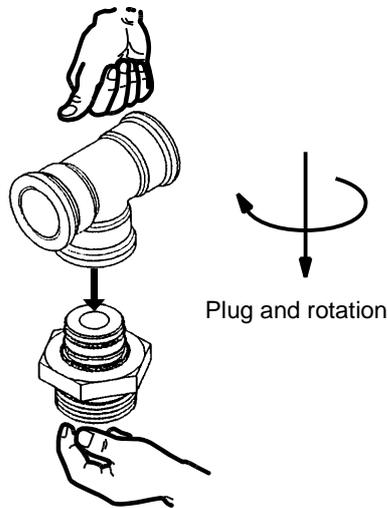
**Assembly Instructions: For the RO Connection**

The range includes two sizes of RO connectors: RO 13 and RO 15.

The RO connection: Plug-In Pivot (male RO) and Plug-On Swivel part (female RO) = Building Block (Turnable).

The Plug-In Pivots are straight parts where as the Plug-In Swivel parts are numerous form parts:  
Elbows, Tees; Crosses . . .

The connection should be done manually by plugging the two parts together to the bottom, with a combined rotation.



A twisting pull should then be applied for control.

Because of the swivelling of the building block (turnable), the RO connection **must** not be used:

- Between the truck and it's trailer, or the axles and the trailer chassis.
- To connect a brake device precariously balanced.

When a RO connection is already used in a kit (swivelling combination). A male/

female screwed connection with a counter nut for firm locking after orientation, being the alternative solution.

**Replacement and interchangeability**

The interchangeability is possible provided that:

- The threads used are in accordance to ISO 4039-1 or ISO 4039-2 (metric).
- The tubes used are in accordance with DIN 74 324/ DIN 73 378 or NFR 12-632 (metric) or ISO 7628.

Only the connection RO (between pivots and swivel parts) is not interchangeable with parts from other manufacturers because of a exclusive design.

The WABCO quick connection fitting system can consequently be used in replacement of both:

- Traditional 24° screwed compression fittings range (with nuts and sleeves).
- All types of other quick connection fitting systems.

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**DIFFERENCE**

**WABCO** (NYSE: WBC) is a leading innovator and global supplier of technologies that improve the safety and efficiency of commercial vehicles. Founded nearly 150 years ago, WABCO continues to pioneer breakthrough products and systems for braking, stability, suspension, transmission automation, and aerodynamics. Today, all of the world's leading truck, bus and trailer

manufacturers have WABCO technologies onboard. In addition, WABCO provides the industry with advanced fleet management solutions and aftermarket services. WABCO reported sales of \$2.9 billion in 2014. The company is headquartered in Brussels, Belgium, and has 11,000 employees worldwide. For more information, visit [www.wabco-auto.com](http://www.wabco-auto.com)