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

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**Oil Bath Air Cleaner**

*Operation:*
Oil bath air cleaner (for air containing a large mount 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.
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.
**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 progress 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: $4 \times 10^6 \text{ m} = 4\text{Å} \ (\text{Angström})$] of the extremely porous granulate.

Since the oil molecules are more than $4\text{Å}$ 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 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.

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

Operation:
a) Control without Integral Unloader 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-
1. Air Dryer

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.
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 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 C to the tyre inflation hose, passing Pin (f). In the event of the pressure in the system exceeding 12+2 bar or 20 \( \frac{1}{2} \) 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. The fall in pressure in Chamber 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 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 \( \frac{1}{2} \) bar respectively 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.

Combined Unloader
975 303 . . . 0
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).
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.
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 bypass 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.
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 through 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 ± 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 ± 0.4 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 ± 0.3 bar Circuits 1 + 2 and 7.5 ± 0.3 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
Drain Valves

**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 remaining 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.
Check Valves

Check Valve
434 01...0

**Purpose:**
To protect the pressurized lines against unintentional venting.

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

When the pressure rises in the supply line, the spring-loaded 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.

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

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.

**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 the feed pipe and the reservoir are equal.

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 vehicle 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 diaphragm 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 Chamber 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 any leakage in 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.
30

1. **Brake Valves**

![Brake Valve With Electrical Switch Or Sensor 461 318 . . . 0](image)

**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 x₁ 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 x₂ 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 x₁ 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.
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 pressure 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
Single Chamber Brake Actuator

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.

Operation:
As soon as air enters the actuator, the 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.
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 3 ... 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:**
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 interlocks 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.

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

**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.
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).
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.

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.

Version I
Hand Brake Valves

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 fall 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

**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 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 (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.
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 (p42 = 8 bar, p2 = 6.5 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.
**Relay Valves**

**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.

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 operated 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.

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**Relay Valve**

(Plastic Type)

973 006 . . . 0

**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.
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 Port2 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.
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 axe 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 Valves

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) open 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 Load Sensing Valves

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 (f) 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 identic 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 identic 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 reduction 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 identic 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 tensile 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 compressed 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.
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 remaining pressure in port 2 is exhausted via port 1.

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.
1. **Trailer Control Valve with predominance**

973 002 . . . 0

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**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.
1. **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 (C), through chamber (B), 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, 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 outlet (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 (l) 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 compressed 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 Valves

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 ± 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

**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 relical 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 oxidizing agents. (Use of chlorinated cleansing agents is therefore to be avoided). Resistance against special substances can be given on request.
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.
**Duo-Matic Quick Coupling**

**For Trailers**

*Duo-Matic 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.

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**Duo-Matic Quick Coupling**

**For Semi-trailers**

*Duo-Matic 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.