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(54) Title: LIFT AXLE CONTROL VALVE ASSEMBLY FOR A MOTOR VEHICLE

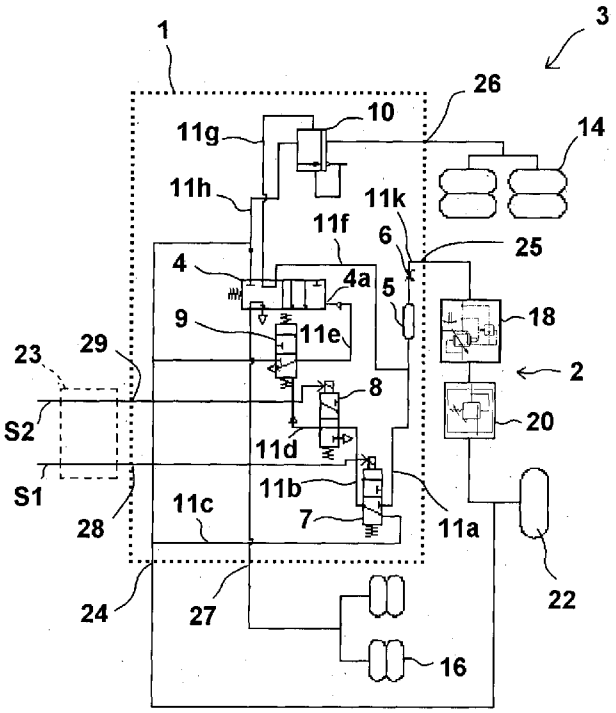


Fig. 2

(57) Abstract: The invention refers to a lift axle control valve assembly (1) for a lift axle suspension system, said lift axle control valve assembly (1) comprising: a pneumatic spool valve (4) for adjusting the air volume. of at least a suspension bellow (14) and a lift bellow (16), a pressure differential valve (9) for controlling said spool valve (4), an electrically actuated pneumatic valve device (7, 8) for receiving at least one electric control signal (S1, S2) and for controlling said pressure differential valve (9), and a relay valve (10) controlled by said pneumatic spool valve (4), wherein said lift axle control valve assembly (1) comprises a multilayer construction with at least two valve levels and at least two layers comprising air passages (11 a, 11 b, 11c, 11d, 11e 11f, 11g, 11 h, 11 k) for conducting air, wherein said valve levels are separated by at least two layers, wherein said valves (are positioned in said valve levels an connected with each other by said air passages (11) of said layers.

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Lift axle control valve assembly for a motor vehicle

Background of the invention

The invention relates to a lift axle control valve assembly to be used in a lift axle suspension system of a commercial vehicle, further to a lift axle suspension system comprising such a lift axle control valve assembly, and a vehicle, in particular a commercial vehicle, comprising such a lift axle suspension system.

A lift axle suspension system of a commercial vehicle comprises in general suspension bellows (like the other axles) for damping and for adjusting the distribution of the axle load between the axles of the vehicle, and additionally lift bellow capable for lifting the axle in order to detach the wheels of the lift axle from ground; further, pneumatic valves for controlling these bellows are provided.

A lift axle suspension system in a commercial vehicle enables the following functions:
- Automatically raising or lowering the lift axle depending on vehicle load condition,
- Override to raise the lift axle when the vehicle is fully loaded for better traction and maneuverability of the vehicle. This override can be initialized manually or by a control unit.

Preferably a damping delay is provided for maintaining the axle position during road undulations. The valve assembly often comprises a solenoid valve which can be used to keep the lift axle during an ignition off condition in its

lowered position in order to avoid theft of wheels. Further a relay valve may be provided for quick response for changing the axle during manual override.

Raising or lowering the axle is achieved through pneumatically actuated valves, which in turn receive appropriate pneumatic and/or electrical signals.

Existing lift axle control valve assemblies can be comprised of essentially a combination of a spool valve, a damping reservoir, a Solenoid valve and a switch, e.g. a double throw pressure switch; the axle control valve assembly works e.g. with an external electrical relay and two external relay valves.

One disadvantage of those prior art lift axle control valve are the high costs of manufacture due to separate cast bodies for the individual valves (Lift axle control valve and Relay valve) and piping to join them together.

Another disadvantage of the known art is that the separate air exhaust ports of the valves have to be separately protected against water and dust entry.

Another disadvantage of the known art is that the control of an external relay valve connected to the suspension bellow is directly performed without a damping. This results in more air consumption due to frequent exhaust of air from suspension bellow when the vehicle is passing through bump road condition.

A further disadvantage of the known art lift axle control valve can be seen in the fact that load sensing is performed through a double throw pressure switch. This results in more inconsistency of pressure sensing and it affects the reliability of the system.

A still further disadvantage of the known art is that a lowering of the lift axle during ignition off condition has to be achieved through an external electrical relay. This affects the reliability of the system.

It is therefore an object of the invention to provide a lift axle control valve assembly, which provides a high reliability at relatively low costs.

Further objects of the invention are to provide a lift axle suspension control system comprising such a lift axle control valve and a vehicle with such a pneumatic system.

Summary of the invention

The lift axle control valve assembly according to the invention is defined in claim 1. Further a lift axle suspension control system comprising this lift axle control valve assembly, lift axle suspension system with this lift axle suspension control system, and a vehicle comprising this lift axle suspension system are provided.

The present invention enables an integration of at least a spool valve, a pressure differential valve, an electrically actuated pneumatic valve device (solenoid valve device) and a relay valve, preferably further a damping reservoir, in a modular way. According to a preferred embodiment these elements are integrated in a multi-layer modular construction. The electrically actuated pneumatic valve device can in particular comprise two solenoid valves, preferably on/off- valves.

The lift axle control valve assembly enables a reduced plumbing on the vehicle. The spool valve and pressure differential valve are preferably integrated into a single body, which receives the relay and two solenoid valves such that the integration is of modular construction.

Said multilayer construction permits flexibility in connecting the air passages between the functional groups of components, said layers being preferably flat bodies with cavities and passages, which results in simplified manufacture and hence reduced costs.

A further advantage of the present invention is that the load sensing through the pneumatically operated pressure differential valve with adjustable pressure setting results in more consistent pressure sensing throughout life time. This can increase the reliability of the system.

According to a further preferred embodiment of the present invention the signal from the load sensing valve is first passing through a damping volume and is afterwards used to actuate the relay valve piston which results in reduced air consumption by avoiding frequent exhaust of air from suspension bellows.

According to a further preferred embodiment a first electro-pneumatic (solenoid) valve is provided to be controlled by a ignition function signal. Preferably air is supplied from an auxiliary reservoir passing through the ignition solenoid valve and giving signal for charging the suspension bellow by means of the relay valve.

The invention is explained in more detail below by means of preferred embodiments shown in the drawings, wherein

Fig. 1 is an electro-pneumatic diagram of a suspension system according to the prior art;

Fig. 2 is an electro-pneumatic diagram of a suspension system according to an embodiment of the invention;

Fig. 3 is a sectional view of a lift axle control valve assembly according to an embodiment of the invention,
Fig. 4 is a detail of Fig. 3 showing an air flow between the solenoid valves;
Fig. 5 is a perspective view of the second layer;
Fig. 6 is a cross sectional view showing the pressure differential valve and spool valve;
Fig. 7 a further sectional view of a part of the lift axle control valve assembly from another side;
Fig. 8 a top view of the third layer 43;
Fig. 9 a perspective view of the relay valve;
Fig. 10 a further sectional view of the top part; and
Fig. 11 a further sectional view of the top part.

Description of the embodiments

Referring to figure 1, a suspension system according to the prior art is shown. The lift axle control valve assembly 101 comprises a spool valve 104, actuated via a solenoid valve 103, a damping reservoir 105 and a double throw pressure switch 106. The solenoid valve 103 and the double throw pressure switch 106 are actuated through electrical signals, which may be output from a device 108, e.g. on basis of a relay. The deliveries from lift axle control valve 101 feed to a signal port of two external relay valves 110 and 112. The delivery of relay valve 110 feeds to the suspension bellow 114 and the delivery of relay valve 112 feeds to the Lift bellow 116.

A reservoir 122 is provided for pressure supply; a pressure limiting device 120 and an automatic load detection valve 118 are provided for supplying pressure in dependence of the axle load to the spool valve 104. The air flow outside the lift axle control valve assembly 101 is realized by pipings 111, for example solid pipes or flexible pipes/hoses.

This construction enables a lift axle application during load change, manual override and ignition conditions.

Figure 2 discloses one embodiment of an inventive lift axle suspension system 3 comprising a lift axle suspension control system 2, suspension bellows 14, lift axle bellows 16 and a reservoir (pressure tank) 22. The lift axle suspension control system 2 comprises a lift axle control valve assembly 1 visualized by dotted lines, a pressure limiting device 20 and an automatic load detection valve 18 for supplying pressure in dependence of the axle load.

The lift axle control valve assembly 1 comprises a first supply port (air inlet) 24 connected to the reservoir 22, a second supply port (air inlet) 25 connected to the automatic load detection valve 18, a first delivery port (air outlet) 26 connected to the suspension bellows 14 and a second delivery port (air outlet) 27 connected to the lift bellow 16. The lift axle control valve assembly 1 comprises further a first electric signal input 28 for receiving a ignition function signal S1 and a second electric signal input 29 for receiving a lift control signal S2. These signals may be output from a control unit 23 symbolized by dashed lines; however, such a control unit is not necessary and this embodiment may in particular be realized by using signals S1 and S2 available in the vehicle via a data bus or by separate electric lines. The ignition function signal S1 may be fed from a relevant terminal which provides a voltage if the ignition of the vehicle is in its " on"-position, and the lift control signal S2 may be input by the driver (e.g. via a switch or lever) in order to raise the lift axle.

The reservoir 22 (auxiliary reservoir) outputs system pressure to the first supply port 24 (system pressure supply port); further air pressure is fed via the pressure limiting device 20 and the automatic load sensing valve 18 to the second supply port 25 (signal pressure supply port) thereby serving as signal pressure, which depends on the current axle load.

The lift axle control valve assembly 1 comprises the following relevant elements disclosed in Fig. 2:
a 5/2-spool valve 4, a first 3/2-solenoid valve (electro-pneumatic valve) 7 for receiving the ignition function signal S1, a second 3/2-solenoid valve (electro-pneumatic valve) 8 for receiving the lift control signal S2, a 3/2-pressure differential valve 9 to be pneumatically controlled by a series connection of the solenoid valves 7 and 8 and for controlling the spool valve 4, a damping reservoir 5, a throttle 6 which may be realized by a small orifice hole, and a relay valve 10. Air passages 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h, 11k (air flow passages, air conduits) are provided internally in the lift axle control valve assembly 1 for an air flow between these elements 4 to 10, i.e. damping reservoir 5, throttle 6, solenoid valves 7 and 8, pressure differential valve 9 and relay valve 10.

The spool valve 4 can be switched into two positions. In the first position shown in Fig. 2 it connects the damping reservoir 5 to the control input of the relay valve 10 being connected between the supply port 24 and delivery port 26, i.e. between the reservoir 22 and the suspension bellows 14. In this position a charging of the suspension bellows 14 is possible in dependence of the axle load acting on the automatic load detection valve 18. In its second position the spool valve 4 connects the supply port 24 to the delivery port 27, i.e. provides pressure from the reservoir 22 to the lift bellow 16 for lifting the lift axle and holding the lift axle in its lifted (upper) position. The lift axle can be lowered again by switching the spool valve 4 back into its first position.

The spool valve 4 is controlled by the pressure differential valve 9 which connects the control input 4a of the spool valve 4 to the supply port 24 in dependence of a series connection of the solenoid valves 7 and 8. The first solenoid valve 7 receives the ignition function signal S1 and transmits either the system pressure of supply port 24 or the load dependent pressure of the

second supply port 25 via the air passage 11b to the second solenoid valve 8. The first solenoid valve 7 receives the load dependent pressure of the second supply port 25 via the damping reservoir 5 and an air passage 11a.

The second solenoid valve 8 is either open (transmitting) or shut, in dependence of the lift control signal S2 input by the driver.

If S2 is not activated and the ignition function signal S1 is off, i.e. S1= 0 and S2=0, then the basic constellation of Fig. 2 is realized in which the lift bellow is discharged via the spool valve 16 in order to lower the lift axle. Thus the lift axle remains in its lower position and the wheels of the lift axle cannot be removed.

The spool valve 4 remains in this first position even when the ignition function signal S1 switches to on, as long as the lift control signal S2 remains off thereby holding the second solenoid valve 8 and the pressure differential valve 9 in the position of Fig. 2, in which the pressure differential valve 9 is blocking. The suspension bellows 14 are supplied with system pressure in dependence of the automatic load detection valve 18; however this load dependent pressure supplied to second supply port 25 is first damped (filtered) by the damping reservoir 5 (and the throttle 6) and afterwards supplied to the relay valve 10 via the air passage 11f, the spool valve 4 and the air passage 11g. An air passage 11k can be provided between the second supply port 25 and the damping reservoir 5.

Thus unnecessary variation of the suspension bellows 26 due to the road undulations can be prevented. Thus a damping delay is realized which helps to avoid frequent exhaust of air from suspension bellow when the vehicle is passing through bump road condition which results in reduction of air consumption.

When the driver inputs the lift control signal S2, i.e. S2=1, the second solenoid valve 8 is switched and closed, i.e. blocking the air passage to the control input of the pressure differential valve 9, thereby enabling the pressure differential valve 9 to switch back, thereby switching the spool valve 4 into its activated second position for supplying air to the lift bellow 16. Thus the lift axle is lifted and remains in its lifted position as long as S2=1.

Figure 3 is a sectional view of the lift axle control valve assembly 1 which is realized as a multilayer construction constituting one single body, with first, second, third, fourth layer 41, 42, 43, 44 and first, second, third valve level 51, 52, 53.

At the top of Fig. 3 a first layer 41 made of a metal like aluminum is provided comprising the signal supply port 25, followed by a second layer 42 made of plastic material. Beneath the second layer 42 a valve level 51 is provided, in which the first and second solenoid valves 7 and 8 and the damping reservoir 5 are positioned, the damping reservoir 5 being formed in a central area between the first and second solenoid valves 7 and 8. The throttle 6 can be realized by a small orifice hole in the second layer 42 (or the first layer 41). The passages between the damping reservoir 5 and the first solenoid valve 7 and between the solenoid valves 7 and 8 are realized as air passages 11a, 11b (air conduits) in the second layer 42 and/or the subsequent third layer 43 made of plastic material.

As can be seen in Fig. 3, the air passages 11d and 11f are realized in the third layer 43, and the air passages 11g and 11h are realized in the fourth layer 44.

Fig 5 is a possible embodiment of the second layer 42; the second, third and fourth layer 42, 43, 44 can be casted, die casted or injection molded thereby allowing a good quality at low prices. Air passages 11a, 11b, 11k and bore

holes 47 extend through the layer 42. The air flow passage 11b between the valves 7 and 8 is realized in the second layer 42, as can be seen from the arrow in Fig. 4.

The spool valve 4 and the pressure differential valve 9 are positioned in the subsequent second valve level 52 beneath the third layer 43. They can be integrated, positioned in parallel next to each other, with a common valve casing 61 separating and covering them, as can be seen from Fig. 6, in which the spool valves 4 and pressure differential valve 9 are symbolized by dashed lines, respectively. The second delivery port 27 may be realized in this valve level, and further a first supply port 24 may be provided.

A fourth layer 44 is provided between the second valve level 52 of the valve casing 61 of the spool valve 4 and pressure differential valve 9 and the third valve level 53 with the relay valve 10, which fourth layer 44 provides the air passage 11e between these valves 4 and 9. The first supply port 24 for system pressure and the first delivery port 26 for the suspension bellows 14 are realized at the sides of the valve level 53 of the relay valve 10. A silencer 63 for exhaust can be provided at the bottom part. Further a relay valve piston 10a is shown.

As can be seen from Fig. 3, first and second supply ports and first and second delivery ports 24, 25, 26, 27 can be realized at the top or sides of the multilayer construction.

This multilayer construction comprises e.g. a rectangular cross section, as can be seen from Fig. 5.

The first, second, third, fourth layer 41, 42, 43, 44 and the first, second, third valve level 51, 52, 53 are fixed together by vertically extending bolts 70 pene-

trating the first, second, third, fourth layer 41, 42, 43, 44 and first, second, third level 51, 52, 53, i.e. a bolt and nut arrangement.

Thus an integration with a platform concept with first, second, third, fourth layers 41, 42, 43, 44 (or further layers) permits flexibility in interconnecting the air passages 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h between the spool valve 4, solenoid valve 7, 8 and relay valve 10. This construction gives the automatic lift axle application during load change, manual override and ignition off conditions.

In addition this construction simplifies the manufacturing of the layers without cross holes and without steel balls used for blocking he cross drilled holes normally used for connecting the passages in the lift axle control valve known to the prior art.

Patent claims

1. Lift axle control valve assembly (1) for a lift axle suspension system, said lift axle control valve assembly (1) comprising:
a pneumatic spool valve (4) for adjusting the air volume of at least a suspension bellow (14) and a lift bellow (16),
a pressure differential valve (9) for controlling said spool valve (4),
an electrically actuated pneumatic valve device (7, 8) for receiving at least one electric control signal (S1, S2) and for controlling said pressure differential valve (9), and
a relay valve (10) controlled by said pneumatic spool valve (4),
wherein said lift axle control valve assembly (1) comprises a multilayer construction with at least two valve levels (51, 52, 53) and at least two layers (41, 42, 43, 44) comprising air passages (11a, 11b, 11c, 11d, 11e 11f, 11g, 11h, 11k) for conducting air,
wherein said valve levels (51, 52, 53) are separated by at least two layers (43, 44) of said layers (41, 42, 43, 44),
wherein said pneumatic spool valve (4), said pressure differential valve (9), said electrically actuated pneumatic valve device (7, 8) and said relay valve (10) are positioned in said valve levels (51, 52, 53) an connected with each other by said air passages (11a, 11b, 11c, 11d, 11e 11f, 11g, 11h, 11k) of said layers (41, 42, 43, 44).

2. Lift axle control valve assembly (1) according to claim 1, comprising:
a first electric signal input (28),
a second electric signal input (29),
a first supply port (24) for air supply connected to said spool valve (4) and to be connected to an external reservoir (22),
a second supply port (25) for air supply to be connected to an external load sensing valve (18),
a first delivery port (26) connected to said relay valve (10) and to be

connected to at least one suspension bellow (14),
a second delivery port (27) connected to said spool valve (4) and to be connected to at least one lift bellow (16).

3. Lift axle control valve assembly (1) according to claim 2, further comprising a damping reservoir (5) being connected to said second supply port (25) and being further connected to said electrically actuated pneumatic valve device (7, 8) and/or to said spool valve (4).

4. Lift axle control valve assembly (1) according to claim 2 or 3, wherein said electrically actuated pneumatic valve device (7, 8) comprises a first electrically actuated pneumatic valve (7) connected to said first electric signal input (28) for receiving a first electric control signal (S1) and a second electrically actuated pneumatic valve (8) connected to said second electric signal input (29) for receiving a second electric control signal (S2),

5. Lift axle control valve assembly (1) according to claim 4, wherein said first and second electrically actuated pneumatic valves (7, 8) being connected in series for connecting either said first supply port (24) or said second supply port (25) to a control input of said pressure differential valve (9).

6. Lift axle control valve assembly (1) according to claim 4 or 5, wherein said first electric control signal (S1) is an ignition function signal and/or said second electric control signal (S1) is a lifting control signal for lifting the lift axle.

7. Lift axle control valve assembly (1) according to one of claims 4 to 6, wherein said first and second electrically actuated pneumatic valves

(7, 8) are positioned in a common first valve level (51) of said multilayer construction.

8. Lift axle control valve assembly (1) according to claim 7, wherein said damping reservoir (5) is positioned at least partially in said first valve level (51), in particular between said first and second electrically actuated pneumatic valves (7, 8).

9. Lift axle control valve assembly (1) according to one of the preceding claims, wherein said multilayer construction comprises
a first layer (41) defining an end part of said multilayer construction and comprising an supply port (25),
a second layer (42) connected to said first layer (41) and a subsequent first valve level (51) comprising said electrically actuated pneumatic valve device (7, 8),
a third layer (43) positioned between said first valve level (51) and a second valve level (52) of said spool valve (4),
a fourth layer (44) positioned between said second valve level (52) and a third valve level (53) of said relay valve (10)..

10. Lift axle control valve assembly (1) according to claim 9, wherein a supply port (24) and a delivery port (26) to be connected externally are positioned in said third valve level (53) of said relay valve (10).

11. Lift axle control valve assembly (1) according to claim 9 or 10, wherein said layers (41, 42, 43, 44) and said valve levels (51, 52, 53) of said multilayer construction are fixed together by one or more bolts (70) extending trough all layers (41, 42, 43, 44) and valve levels (51, 52, 53).

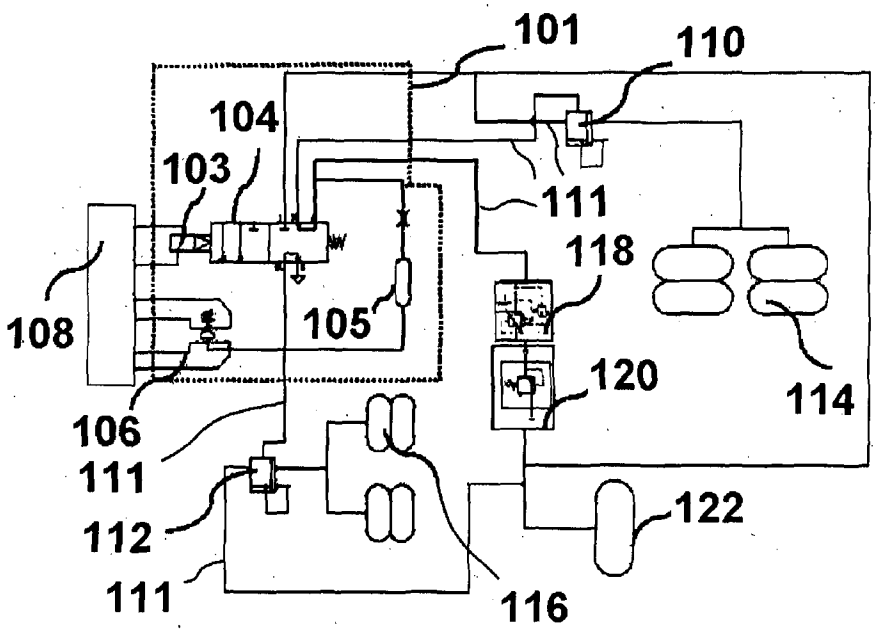
12. Lift axle control valve assembly (1) according to one of claims 9 to 11, wherein said first layer (41) is made of a metal material and at least

one of said second, third and fourth layer (42, 43, 44) is made of a plastic material, in particular as casted, die casted or injection molded parts comprising said air passages (11a, 11b, 11c, 11d, 11e 11f, 11g, 11h, 11k) and bolt holes (47).

13. Lift axle suspension control system (2) for controlling a lift axle suspension system (3) of a commercial vehicle,
said lift axle suspension control system (2) comprising:
a lift axle control valve assembly (1) according to one of the preceding claims,
a load sensing valve (18) for delivering a signal pressure to said lift axle control valve assembly (1) in dependence of an axle weight, and
electric signal lines for inputting electric signals (S1, S2) to said lift axle control valve (1).

14. Lift axle suspension system (3) for a commercial vehicle, comprising:
a lift axle suspension control system (2) according to claim 13,
at least one suspension bellow (14) connected to said lift axle control valve assembly (1), and
at least one lift bellow (16) connected to said lift axle control valve assembly (1).

15. Vehicle comprising a lift axle suspension system (3) according to claim 14.



Prior Art

Fig. 1

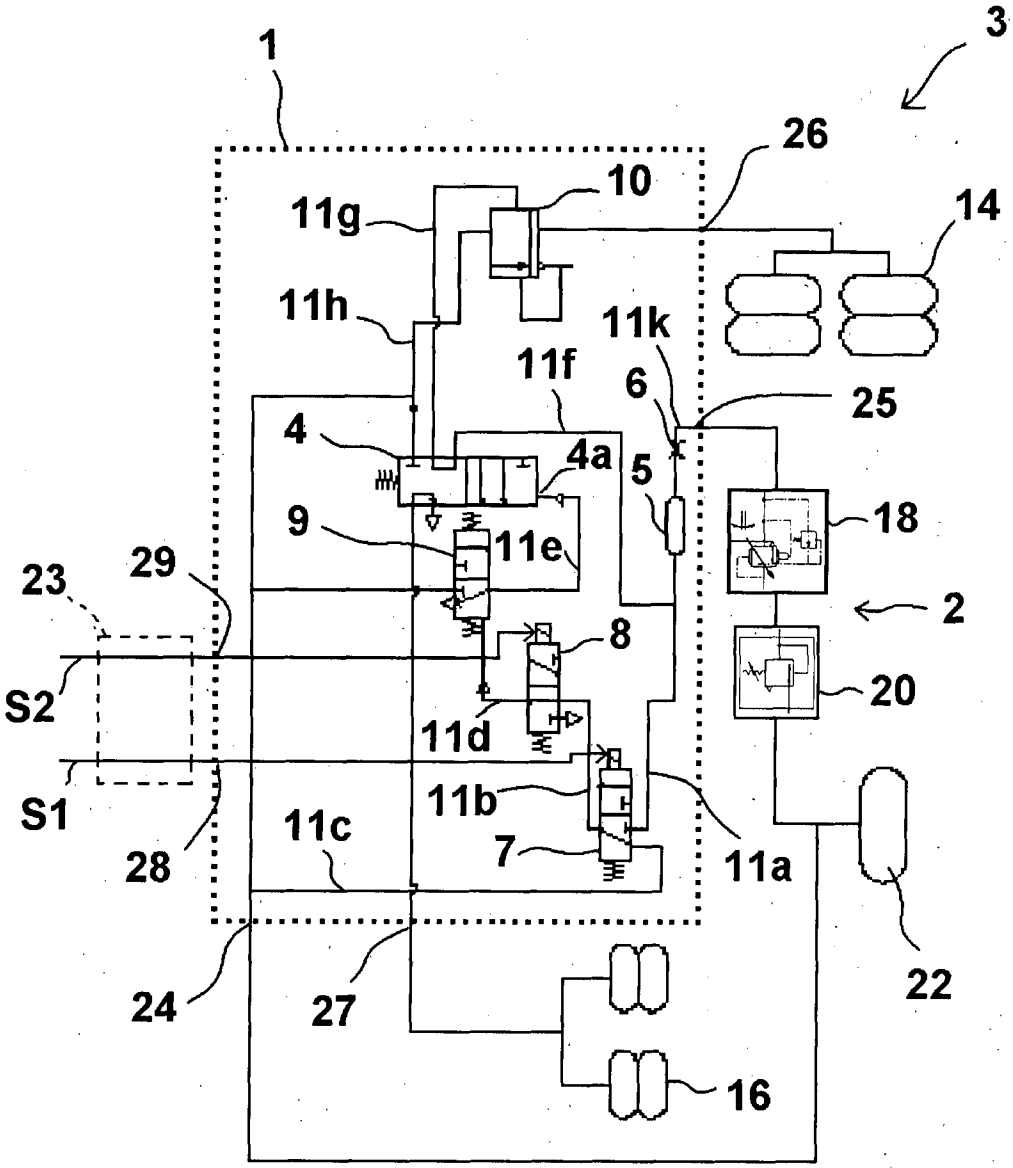

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Fig. 2

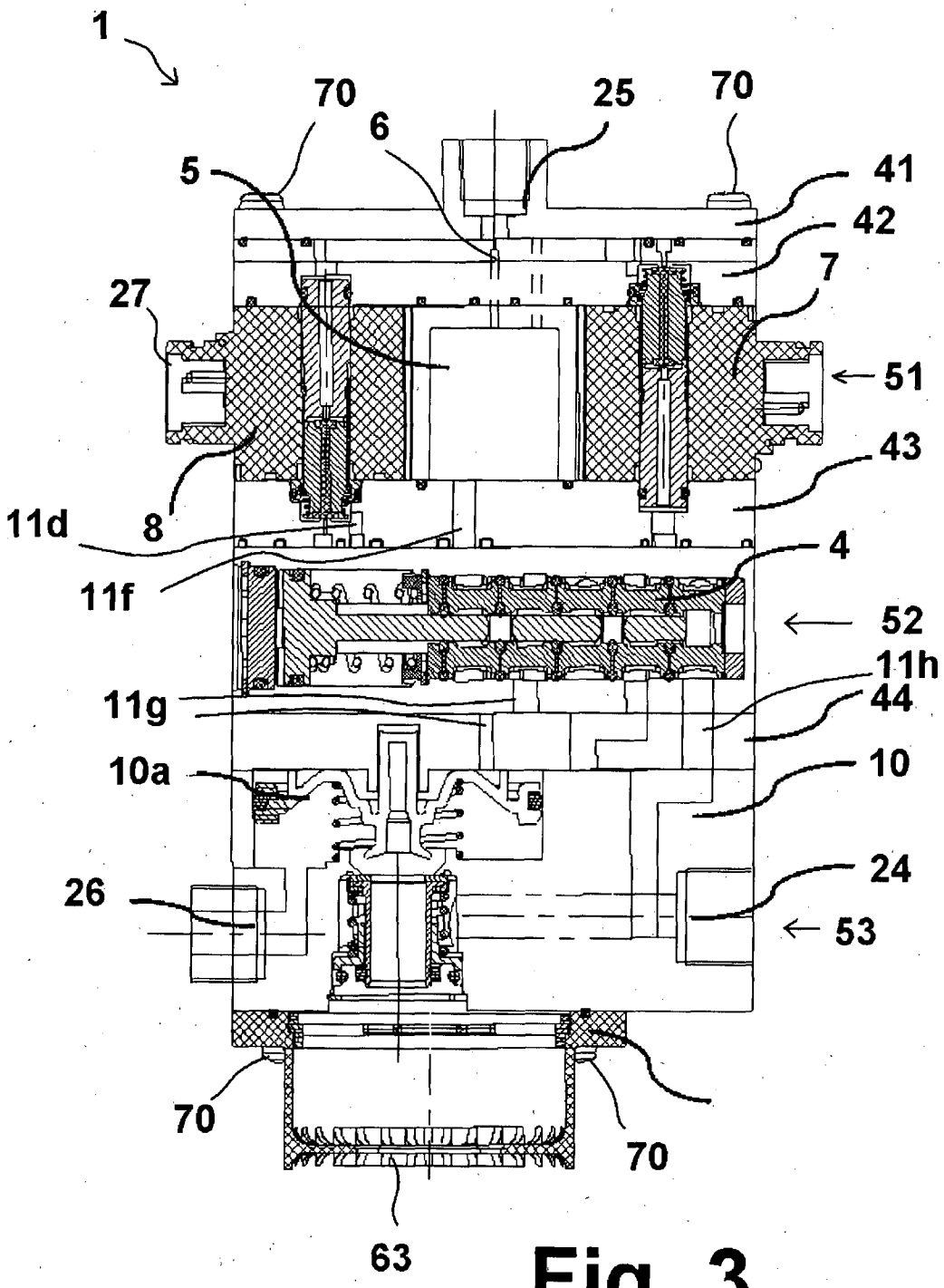

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Fig. 3

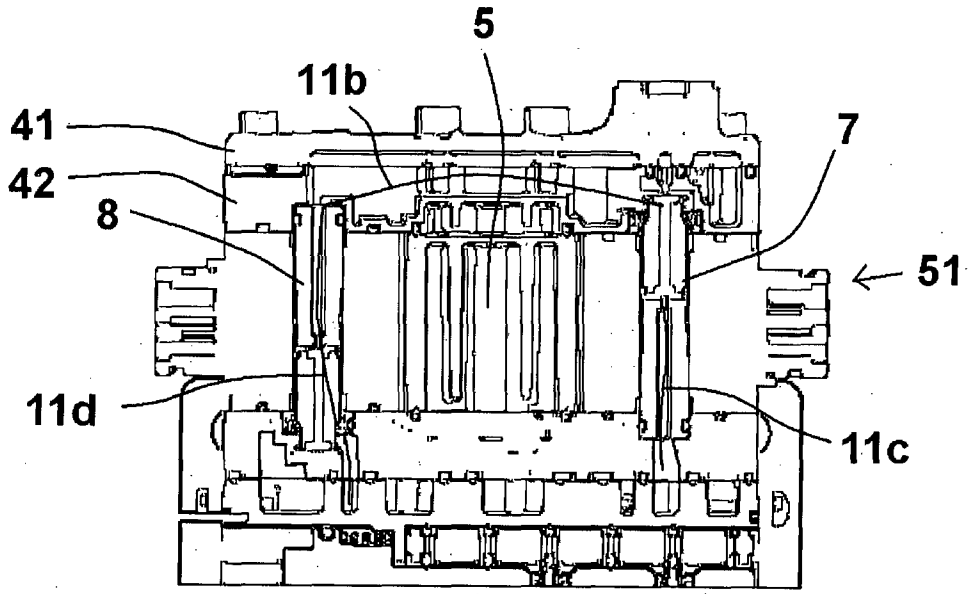


Fig. 4

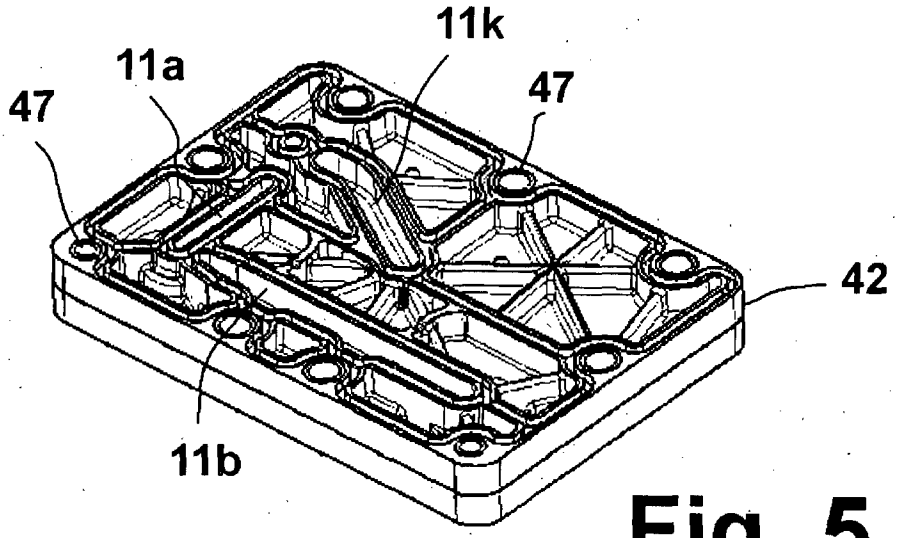


Fig. 5

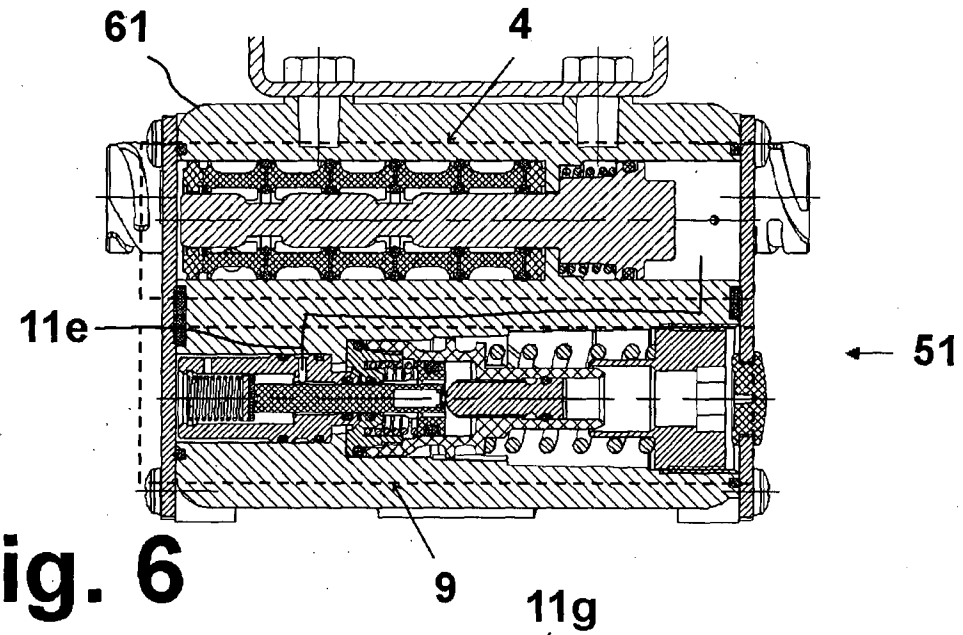


Fig. 6

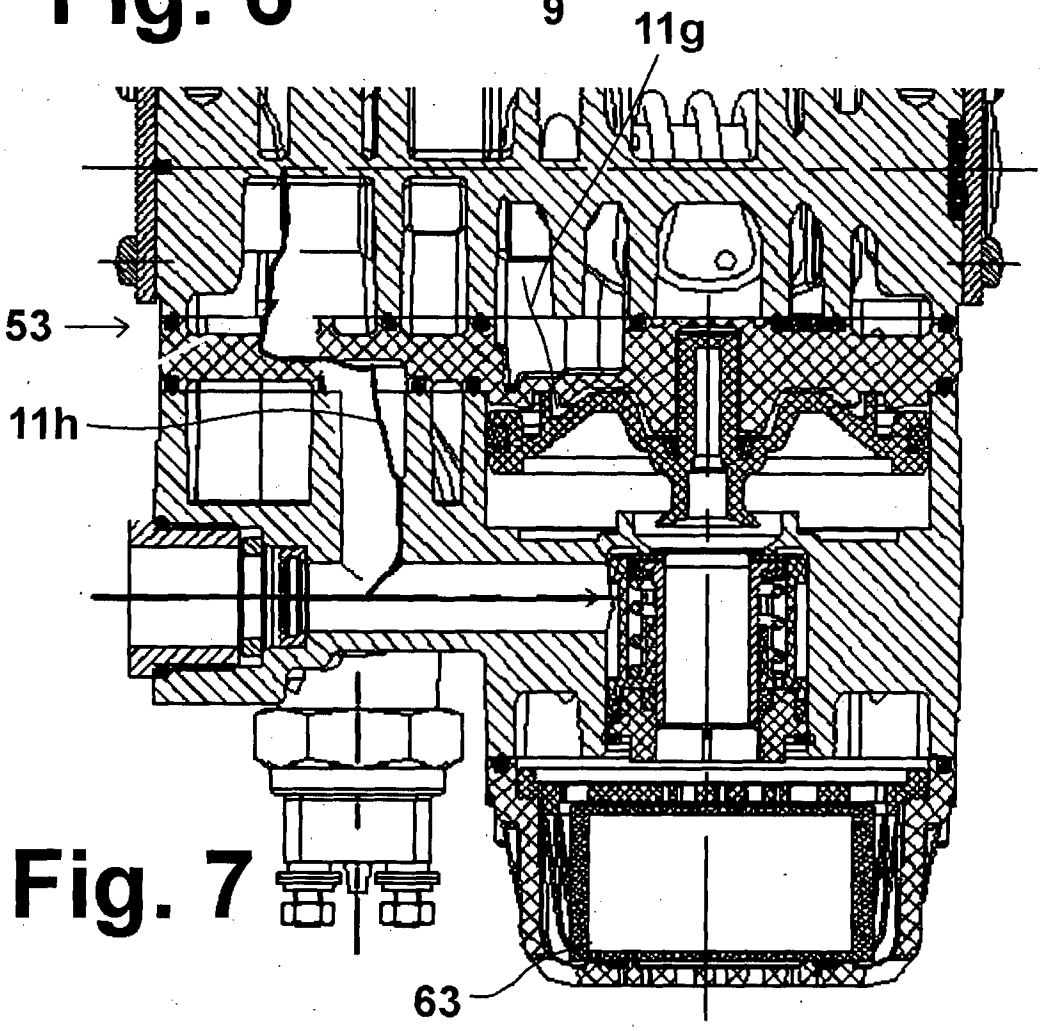


Fig. 7

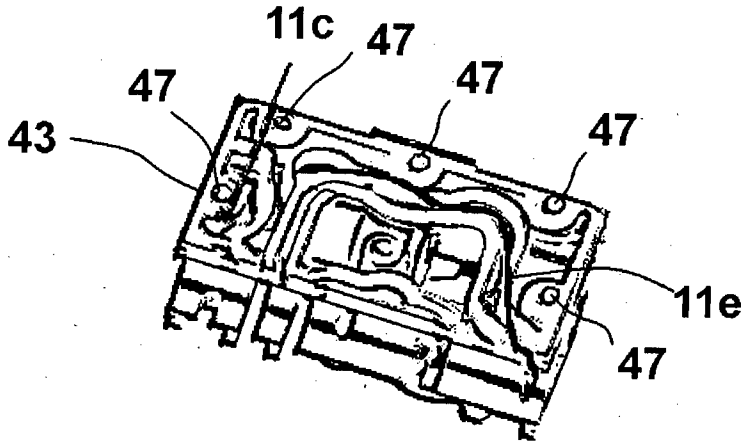


Fig. 8

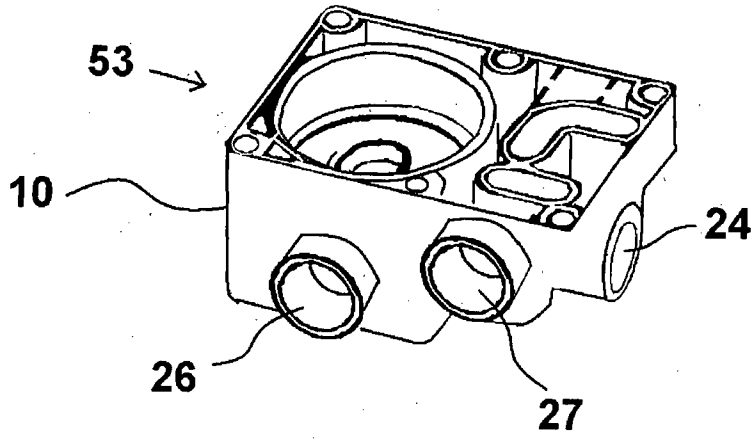


Fig. 9

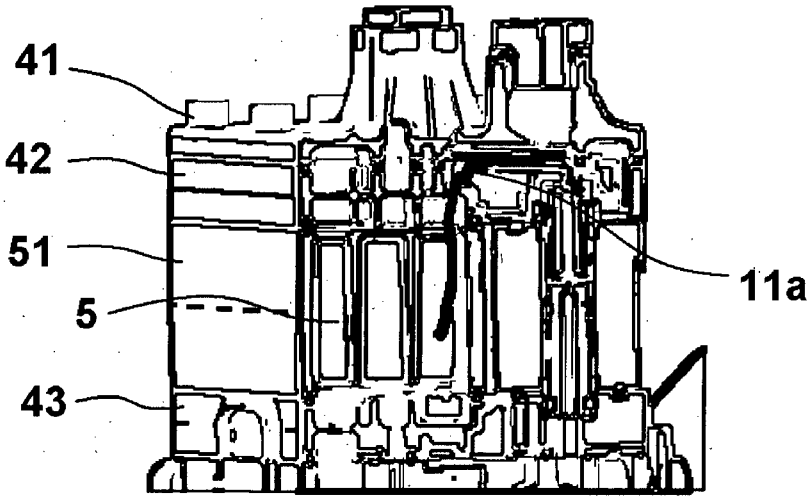


Fig. 10

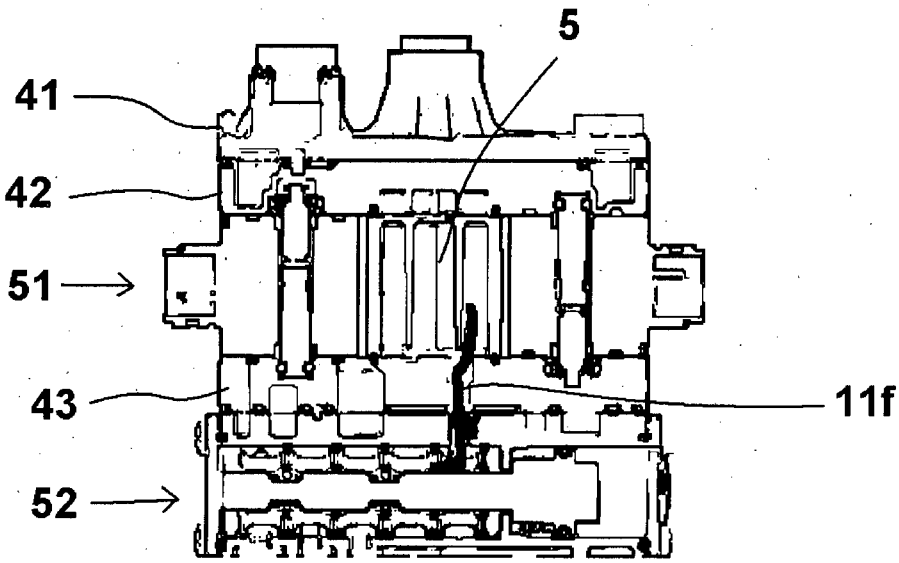


Fig. 11