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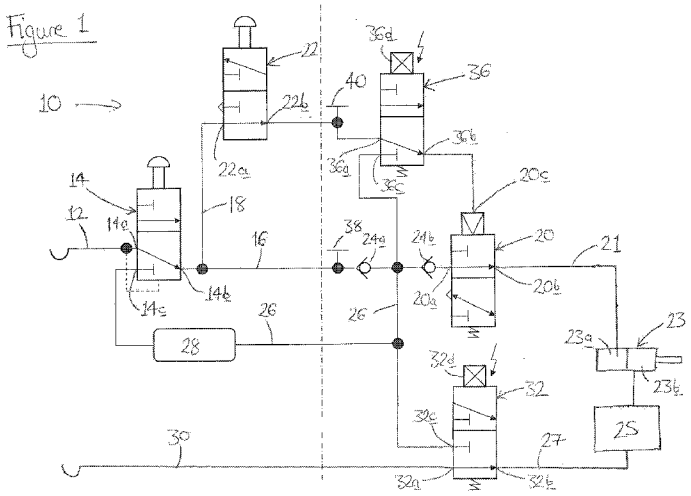
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(54) Title: VEHICLE BRAKING SYSTEM



(57) Abstract: A vehicle braking system (10) comprising a brake actuator (23) which is operable to adopt a brake apply position in which the actuator (23) may apply a braking force to a vehicle wheel and a brake release position in which the actuator (23) may release any braking force applied to a vehicle wheel, the brake actuator (23) having a spring brake chamber (23a) and a spring and being configured such that supply of pressurised fluid to the spring brake chamber (23a) causes the brake actuator (23) to move against the biasing force of the spring to the brake release position and release of pressurised fluid from the spring brake chamber (23a) causes the brake actuator (23) to move under the action of the spring to the brake apply position, the system (10) further including a supply line (2) whereby the spring brake chamber (23a) is, in use, connected to a supply of pressurised fluid, and an emergency brake apply valve (20) which has a control port (20c) which is connected to the supply line (12), the emergency brake apply (1) valve (20) being configured automatically to connect the spring brake chamber (23a) to a low pressure region when the pressure at the control port (20c) falls below a predetermined level, wherein the system further includes an electrically operable emergency braking override valve (36), (36') which has a first port (36a), (36a') which is connected to the supply line (12) and a second port (36b), (20) (36b') which is connected to the control port (20c) of the emergency brake apply valve (20) and which, when supplied with sufficient electrical power, acts to prevent loss of fluid pressure at the control port (20c) of the emergency brake apply valve (20).

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Title: Vehicle Braking System

Description of Invention

The present invention relates to a braking system, particularly, but not exclusively to a braking system for a trailer of a road vehicle comprising a tractor and trailer combination.

Large commercial trailers are typically fitted with two types of brake actuator – a service actuator in which air pressure on a piston or diaphragm pushes a rod which applies mechanical turning force to the input shaft of the brake, and a service/spring actuator which includes, in addition to a service actuator, a spring actuator comprising an internal coil spring which acts on the pushrod, which can be compressed when a second chamber is pressurised. The brakes can be applied therefore by either increasing pressure supplied to the service actuator as normal, and/or by a reducing the pressure supplied to the spring actuator. A common configuration, for example, is a semi-trailer with three axles, the front of which has service actuators and the middle and rear of which has service/spring actuators. Other combinations are possible, however.

In the normal driving condition the spring actuators are pressurised from the compressed air supply line (or trailer reservoir) to hold them off. Graduated braking in response to driving demand for braking is effected via the service actuators.

If the compressed air supply (or trailer reservoir) pressure falls, the pressure to the service actuators falls with it, reducing the applied force to the brake. At the same time, however, the pressure in the spring actuators is reducing by the same amount, which results in substantially the same braking force being maintained until and including when the supply line or reservoir is completely empty. Normally a park valve is also included in the supply line, which allows

the pressure in the spring actuators to be exhausted in order to positively park the trailer.

It is also normal practice to include an emergency apply function to a trailer brake system. This acts when the pneumatic supply line ('red line') to the trailer is disconnected, exhausted or severed (thereby preventing the trailer reservoir from being replenished with compressed air). The emergency apply function acts on either the service actuators or the spring actuators, and can be required due to a fault when the vehicle is moving.

Usually a shunt valve is also included to divert air from the trailer reservoir to defeat the emergency apply function in order to allow the trailer to be moved ('shunted') without connection to a towing vehicle with a compressed air supply. This may be required, for instance, at a distribution depot or ferry terminal.

Emergency braking by the supply of pressurised fluid to the service actuators (i.e. via the service brake line) has an advantage in that this flow of fluid is normally controlled by the electronic braking system (EBS) or anti-lock braking system (ABS) of the trailer. The vehicle can either be immediately brought to a safe stop with the benefit of the anti-lock function, or the emergency brake application can be held off whilst the driver is warned of the situation. The driver may then bring the vehicle to a safe stop at the side of the road using normal service braking.

Emergency braking using the spring actuators, i.e. by the release of fluid from the spring line, can be less complex, but has disadvantages in that it is not normally possible to provide an anti-lock function without additional components which then makes the solution more complex than the service solution. One solution to this problem is presented in DE3522183C1. In the system proposed in this document an electrically operated valve is provided to control the release of pressurised fluid from the spring brake. If wheel-lock is

detected, this valve may be operated as an ABS valve to stop, momentarily, release of fluid from the spring brake.

In an alternative proposal, disclosed in EP1538054, the braking system is provided with a means for preventing the emergency application of the spring brake in the event of loss of pressure in the spring brake circuit, and the service braking circuit downstream of the or each modulator associated with brake actuators on one side of the vehicle is connected to the spring brake line via a shuttle valve. The shuttle valve is configured such that pressurised fluid is supplied to the spring brake line from this portion of the service braking circuit when the fluid pressure in the spring brake line is lower than the pressure in the service brake circuit. Thus fluid from one half of the service braking circuit is used to prevent the application of the spring brake. The service braking circuit may then be used to apply the brakes to bring the vehicle to a halt. The ABS is disabled on the one side of the vehicle, however, to avoid chattering of the spring brake during an ABS intervention, but can be operated as normal on the other side of the vehicle.

A further alternative proposal, disclosed in WO2011/003491, is alleged to be an improvement over the system disclosed in EP1538054. In this proposal, if wheel lock is detected during the emergency application of the spring brakes resulting from loss of pressure in the spring brake circuit, the system acts to direct pressurised fluid from the service circuit to the spring brake circuit to release the spring brakes, whilst at the same time applying the service brakes. Once the pressure in the spring brake chambers is high enough, a “spring store neutralising valve” is operated to isolate the spring brake chambers. The EBS modulator may then use conventional ABS algorithms to modify the braking force applied by the service brakes on both sides of the vehicle without affecting the spring brake.

According to a first aspect of the invention we provide a vehicle braking system comprising a brake actuator which is operable to adopt a brake apply

position in which the actuator may apply a braking force to a vehicle wheel and a brake release position in which the actuator may release any braking force applied to a vehicle wheel, the brake actuator having a spring brake chamber and a spring and being configured such that supply of pressurised fluid to the spring brake chamber causes the brake actuator to move against the biasing force of the spring to the brake release position and release of pressurised fluid from the spring brake chamber causes the brake actuator to move under the action of the spring to the brake apply position, the system further including a supply line whereby the spring brake chamber is, in use, connected to a supply of pressurised fluid, and an emergency brake apply valve which has a control port which is connected to the supply line, the emergency brake apply valve being configured automatically to connect the spring brake chamber to a low pressure region when the pressure at the control port falls below a predetermined level, wherein the system further includes an electrically operable emergency braking override valve which has a first port which is connected to the supply line and a second port which is connected to the control port of the emergency brake apply valve and which, when supplied with sufficient electrical power, acts to prevent loss of fluid pressure at the control port of the emergency brake apply valve.

In one embodiment of the invention the emergency brake apply valve has an input port which is connected to the supply line and a second port which is connected to the spring brake chamber, and is movable between a first position in which the input port is connected to the output port and a second position in which the input port is closed and the output port vents to a low pressure region. In this case, mechanical biasing means may be provided to urge the emergency brake apply valve into the second position, and movement of the emergency brake apply valve from the second position to the first position is achieved by the supply of pressurised fluid to the control input at sufficient pressure to overcome the force of the biasing means.

The brake actuator may further include a service brake chamber, wherein supply of pressurised fluid to the service brake chamber causes the brake actuator to move to the brake apply position. In this case, the system may further include a control line which in use connects a source of a fluid pressure braking demand signal to the service brake chamber via a braking control valve assembly. The brake valve assembly may comprise at least one modulator which has a control port which is connected to the control line for receipt of a fluid pressure braking demand signal, a supply port which is connected to a source of pressurised fluid, a delivery port which is connected to the service brake chamber, and an exhaust port which vents to a low pressure region, the modulator being operable to move between a build configuration in which the supply port is connected to the delivery port whilst the exhaust port is closed, a hold configuration in which the exhaust port and the supply ports are closed and an exhaust configuration in which the delivery port is connected to the exhaust port whilst the supply port is closed.

In one embodiment of the invention, the vehicle braking system further comprises a pressurised fluid reservoir which is connected to the control line via a brake apply valve. In this case, the brake apply valve may be movable between a first configuration in which the brake apply valve substantially prevents flow of fluid from the pressurised fluid reservoir to the control line, and a second in which the brake apply valve allows flow of fluid from the pressurised fluid reservoir to the control line.

A non-return valve may be provided in the supply line upstream of the input port of the emergency brake apply valve, the non-return valve permitting flow of fluid along the supply line to the emergency brake apply valve whilst substantially preventing flow of fluid in the opposite direction. In this case, the pressurised fluid reservoir may be connected to the supply line downstream of the non-return valve.

A second non-return valve may be provided in the supply line upstream of the input port of the emergency brake apply valve, the second non-return valve also permitting flow of fluid along the supply line to the emergency brake apply valve whilst substantially preventing flow of fluid in the opposite direction. In this case, the pressurised fluid reservoir may be connected to the supply line between the two non-return valves.

In one embodiment of the invention, the emergency braking override valve has a third port which is connected to the supply line between the first port of the emergency brake apply valve and the connection to the control port of the emergency brake apply valve. In this case, the third port may be connected to the supply line downstream of the non-return valve. Where two non-return valves are provided, the third port is preferably connected to the supply line between the two non-return valves.

The emergency braking override valve may be movable between a first position in which its first port is connected to its second port, whilst its third port is closed, and a second position in which its third port is connected to its second port whilst its first port is closed.

The emergency braking override valve may be provided with mechanical biasing means to urge the emergency braking override valve into the first position, movement of the emergency braking override valve from the first position to the second position being achieved by the supply of electrical power to the emergency braking override valve.

In another embodiment of the invention the emergency braking override valve is movable between a first position in which its first port is connected to its second port, and a second position in which flow of fluid between its second port and its first port is substantially prevented. In this case, the emergency braking override valve is preferably provided with mechanical biasing means to urge the emergency braking override valve into its first position, and

movement of the emergency braking override valve from the first position to the second position being achieved by the supply of an electrical current to the emergency braking override valve.

Embodiments of the invention will now be described, by way of example only, with reference to the following figures, of which,

FIGURE 1 shows a schematic illustration of a first embodiment of braking system according to the invention in normal service braking mode,

FIGURE 2 shows a schematic illustration of the first embodiment of braking system according to the invention in autonomous or forced braking mode,

FIGURE 3 shows a schematic illustration of the first embodiment of braking system according to the invention in normal parking mode,

FIGURE 4 shows a schematic illustration of the first embodiment of braking system according to the invention when the supply line is disconnected from the source of pressurised fluid,

FIGURE 5 shows a schematic illustration of the first embodiment of braking system according to the invention in emergency braking override mode,

FIGURE 6 shows a schematic illustration of a second embodiment of braking system according to the invention in normal braking mode, and

FIGURE 7 shows a schematic illustration of the second embodiment of braking system in emergency braking override mode.

Referring now to Figure 1 there is shown a braking system 10 for a trailer of a vehicle comprising a tractor and a trailer or semi-trailer. The braking system comprises a supply line 12 which is adapted to be connected to a source of pressurised fluid, typically compressed air, on a tractor to which the trailer is coupled. The supply line 12 extends first input 14a of a shunt valve 14, the

output 14b of the shunt valve 14 being connected to a junction between an emergency apply line 16 and a park line 18. The emergency apply line 16 extends to an input 20a of an emergency apply valve 20, whilst the park line 16 extends to an input 22a of a park valve 22. The output 20b of the emergency apply valve 20 is connected to the spring brake chamber 23a of a service / spring actuator 23 via a spring brake line 21. The emergency apply valve 20 is also provided with a control input 20c which is connected to an output 22b of the park valve 22.

Two one-way check valves 24a, 24b are provided in the emergency apply line 16, both being oriented to allow flow of fluid from the shunt valve 14 to the emergency apply valve 20 but to prevent flow of fluid in the other direction along the emergency apply line 16, i.e. away from the emergency apply valve 20.

A trailer reservoir supply line 26 extends from the emergency apply line 16 between the two check valves 24a, 24b to a pressurised fluid reservoir 28 mounted on the trailer. An outlet from the trailer reservoir 28 is connected to a second input 14c of the shunt valve 14.

There is also provided a control line 30 which is adapted to be coupled to a braking control line on a tractor to which the trailer is coupled, the braking control line carrying a fluid pressure braking demand signal generated when a driver of the vehicle operates a brake pedal or the like to indicate a need for braking. The control line 30 is connected to a first input 32a of a brake apply valve 32, an output 32b of the brake apply valve 32 being connected to control input of a conventional electrical braking system (EBS) control valve assembly 25 via a service brake line 27. The EBS control valve assembly 25 typically comprises at least a modulator and is connected to the service brake chamber 23b of a brake actuator 23. The modulator has a control port which is connected to the control line for receipt of a fluid pressure braking demand signal, a supply port which is connected to a source of pressurised fluid, a

delivery port which is connected to the service brake chamber, and an exhaust port which vents to a low pressure region, and is operable to move between a build configuration in which the supply port is connected to the delivery port whilst the exhaust port is closed, a hold configuration in which the exhaust port and the supply ports are closed and an exhaust configuration in which the delivery port is connected to the exhaust port whilst the supply port is closed. Various configurations of modulator are well known to those skilled in the art. The EBS control valve assembly 25 is operable to provide anti-lock braking control.

A second input 32c of the brake apply valve 32 is connected to the trailer reservoir supply line 26.

The system is also provided with an emergency braking override valve36 which has a first port 36a which is connected to the output 22b of the park valve 22, a second port 36b which is connected to the control input 20c of the emergency apply valve 20, and a third port 36c which is connected to the emergency apply line 16 between the first and second one-way check valves 24a, 24b.

The shunt valve 14 is movable between a first position (illustrated in Figure 1) in which the first input 14a is connected to the output 14b whilst the second input 14c is closed, and a second position in which the first input 14a is closed and the second input 14c is connected to the output 14b. In this example, the shunt valve 14 is adapted to be moved manually between the first and second positions.

The emergency apply valve 20 is movable between a first position (illustrated in Figure 1) in which the first input 20a is connected to the output 20b and a second position in which the first input 20a is closed and the output 20b vents to a low pressure region (typically to atmosphere). Mechanical biasing means (in this example a spring) is provided to urge the emergency apply valve 20

into the second position. Movement of the emergency apply valve 20 from the second position to the first position is achieved by the supply of pressurised fluid to the control input 20c at sufficient pressure to overcome the force of the biasing means.

The park valve 22 is movable between a first position (illustrated in Figure 1) in which the input 22a is connected to the output 22b and a second position in which the input 22a is closed and the output 22b vents to a low pressure region (typically to atmosphere). In this example, the park valve 22 is adapted to be moved manually between the first and second positions.

The brake apply valve 32 is movable between a first position (illustrated in Figure 1) in which the first input 32a is connected to the output 32b, whilst the second input 32c is closed, and a second position in which the first input 32a is closed and the third input 32c is connected to the output 32b. The brake apply valve 32 is electrically operable, in this example, by means of a solenoid. Mechanical biasing means (in this example a spring) is provided to urge the brake apply valve 32 into the first position. Movement of the brake apply valve 32 from the first position to the second position is achieved by the supply of an electrical current to the solenoid 32d.

The emergency braking override valve 36 is movable between a first position (illustrated in Figures 1 to 5) in which its first port 36a is connected to its second port 36b, whilst its third port 36c is closed, and a second position (illustrated in Figure 6) in which its third port 36c is connected to its second port 36b whilst its first port 36a is closed. The passage of fluid from the supply line 16 to the control input 20c of the emergency apply valve 20 via the park valve 22 is therefore not affected by the emergency braking override valve36 when the emergency braking override valve 36 is in its first portion. The emergency braking override valve 36 is electrically operable, in this example, by means of a solenoid 36d. Mechanical biasing means (in this example a spring) is provided to urge the emergency braking override valve 36 into the

first position. Movement of the emergency braking override valve 36 from the first position to the second position is achieved by the supply of an electrical current to the solenoid 36d.

The braking system is operated as follows.

When the trailer is coupled to a tractor, and there is normal service braking, the braking system is configured as shown in Figure 1. The shunt valve 14 and park valve 22 are set to their first positions, and there is no supply of electrical current to the brake apply valve 32. The supply line 12 is connected to a source of pressurised fluid on the tractor, and pressurised fluid passes to the control input 20c of the emergency apply valve 20 via the park line 18 and the park valve 22. The presence of pressurised fluid at its control input 20a causes the emergency apply valve 20 to move to its first position whereby the first input 20a is connected to the output 20b. As a result, pressurised fluid passes along the emergency apply line 16 via the shunt valve 14, and then to the spring brake chamber 32a of the brake actuator 32b via the emergency apply valve 20 and spring brake line 21. The fluid pressure in the spring brake chamber 32a overcomes the biasing force of the spring and the actuator acts to release the brake.

Pressurised fluid also passes from the tractor to the trailer reservoir 28 via the trailer reservoir supply line 26 so that the trailer reservoir 28 is charged with pressurised fluid.

When a driver of the vehicle generates a fluid pressure braking demand signal, this passes along the braking control line 30 to the EBS valve assembly 25, resulting in the supply of fluid pressure to the service braking chamber 23b of the brake actuator 23, and the gradual application of brake pressure in line with driver demand for braking. A conventional anti-lock function may be provided by means of modulating valves in the EBS valve assembly 25.

The system 10 may be operated to provide service braking even when there is no fluid pressure braking demand signal by the supply of an electrical current to the solenoid 32d of the brake apply valve 32. This causes the brake apply valve 32 to move to its second position in which the first input 32a is closed and the second input 32c is connected to the output 32b, as illustrated in Figure 2. Pressurised fluid then passes from the supply line 12 through the shunt valve 14 to the emergency apply line 16, through the first one way check valve 24a to the trailer reservoir supply line 26, then on to the EBS control valve assembly 25 via the brake apply valve 32. The service brake chamber 23b of the actuator 23 may therefore be pressurised autonomously, i.e. without driver initiated braking demand, or with a higher pressure than provided by the fluid pressure braking demand signal. Such automonous service braking may be required in an automatic stability control system.

When operating in normal service braking mode, the spring brake can be applied by moving the park valve 22 from its first position to its second position, as illustrated in Figure 3. This causes fluid pressure at the control input 20c of the emergency apply valve 20 to be vented to atmosphere at the park valve 22, and the emergency apply valve 20 to move under the action of its biasing means to its second position in which its output 20b vents to atmosphere, and its input 20a is closed. Pressure is therefore released from the spring brake chamber 23a of the brake actuator 23 at the emergency apply valve 20 and the actuator 23 moves in response to the spring force to apply the brake.

If the supply line 12 is disconnected from its supply of pressurised fluid, and there is no supply of electrical current to the brake apply valve 32, the braking system adopts the configuration shown in Figure 4. The release of pressure from the supply line 12 and the park line 18 causes the emergency apply valve 20 to move under the action of the biasing means to its second position in which the output is exhausted to atmosphere and the input 20a is closed. Fluid pressure is therefore released from the spring brake chamber 23a of the

brake actuator 23 and vented to atmosphere at the emergency apply valve 20, and the actuator 23 moves in response to the spring force to apply the brake.

It may, not, however, be desirable to allow this emergency application of the vehicle spring brakes to take place, and if there is no problem with the electrical power supply to the system 10, the system can be operated to prevent this, specifically by the supply of electrical power to the solenoid 36d of the emergency braking override valve 36. This causes the emergency braking override valve 36 to move to its second position wherein the control input 20c of the emergency apply valve 20 is connected to the portion of the emergency apply line 16 between the two one-way check valves 24a, 24b, rather than to the portion of the supply line 16 upstream of the two one-way check valves 24a, 24b. Pressurised fluid thus flows from the reservoir 28 to the control input 20c of the emergency apply valve 20, maintained it in or returning it to its first position. Pressurised fluid can then also flow from the reservoir 28 to the spring brake chamber 23a via the emergency apply valve 20, to release the spring brake. This is illustrated in Figure 5.

Emergency braking can then, if desired, be effected using the service brake by the supply of electrical power to the solenoid 32d of the brake apply valve 32. Just as described above in relation to Figure 2, this causes the brake apply valve 32 to move to its second position in which the first input 32a is closed and the second input 32c is connected to the output 32b. In this case however, pressurised fluid passes from the reservoir 28 to the EBS control valve assembly 25 via the brake apply valve 32 and the service brake line 27 to effect service braking. As with conventional service braking, the EBS valve assembly can use conventional ABS control algorithms to modify the emergency braking in accordance with standard anti-lock control procedures if wheel slip is detected.

The braking system 10 may include a pressure sensor 38 in the emergency apply line 16 between the first one way valve 24a and the connection to the

park line 18. If this pressure sensor 38 is connected to an electronic control unit (ECU not shown) which controls operation of the electrically operated valves in the braking system (including the brake apply valve 32 and the electrically operated valves in the EBS control valve assembly 25), the ECU can be programmed always to energise the emergency override valve 36 to override the emergency application of the spring brake whenever a sudden drop in the pressure in the emergency apply line 16 is detected, or whenever the pressure in the emergency apply line 16 falls below a predetermined level. The ECU may alternatively be programmed to energise the emergency braking override valve 36 to override the emergency application of the spring brake when a sudden drop in the pressure in the emergency apply line 16 is detected, or when the pressure in the emergency apply line 16 falls below a predetermined level, but only if certain other predetermined criteria are met – if the vehicle speed exceeds a predetermined level, or if the fluid pressure in the trailer reservoir 28 exceeds a predetermined level, for example.

Whilst the ECU may also be programmed always to activate the brake apply valve 32 when the emergency braking override valve 36 is activated (i.e. to effect emergency service braking when the emergency application of the spring brake is prevented) this need not be the case. The ECU may be programmed to activate a signal warning a driver of the vehicle that the supply of pressurised fluid to the supply line 12 has been broken via a CAN bus connection to the driver's cab. The signal may be visual – a warning light or the like, or audible – a buzzer, bell or the like, or preferably both. The driver may then make a decision to activate the brakes himself, in which case, an electrical braking demand signal is transmitted directly to the brake valve assembly 25 via a CAN bus to effect service braking.

The ECU may further be programmed such that, once the vehicle has come to a halt, it operates the EBS control valve assembly 25 to hold the pressure in the service brake chamber 23b of the brake actuator 23, whilst the emergency braking override valve 36 is deenergised. This causes the control input 20c of

the emergency apply valve 20 to be vented to atmosphere, allowing the emergency apply valve 20 to move to its second position, and venting the spring brake line 21 and spring brake chamber 23a. Once the pressure in the spring brake chamber 23a is exhausted, the spring brake is applied, and the EBS control valve assembly 25 may be operated to exhaust the service brake chamber 23b.

Release of the spring brake occurring as a result of actuation of the park valve 22 as described in relation to Figure 3 above may also be overridden by actuation of the emergency braking override valve 36. In order to do this, a further pressure sensor 40 may be provided in the park line 18 between the control input 20c of the emergency apply valve 20 and the output 22b of the park valve 22. The further pressure sensor 40 may also be connected to the braking ECU which may be programmed to respond to a sudden reduction in pressure signal from the further pressure sensor 40 in the same way as described above in relation to the first pressure sensor 38.

It should be appreciated that, whilst in the embodiment of the invention described above two pressure transducers 38, 40 are provided, this need not be the case. The further pressure transducer 40 can be provided instead of the first pressure transducer 38, as the further pressure transducer 40 also detects the loss of pressure in the supply line 16. The provision of both pressure transducers 38, 40 allows the system to discriminate between loss of pressure to the control input 20c of the emergency apply valve 20 as a result of loss of supply pressure from the loss of pressure caused by operation of the park valve 22.

For completeness, it should be appreciated that the shunt valve 14 may be operated to release the parking brake without the need for electrical power, for example if the trailer is disconnected from a tractor but needs to be moved around a depot or the like. This can be done by moving the park valve 22 to its first position, and moving the shunt valve 14 to its second position.

Pressurised fluid flows from the trailer reservoir 28 to the control input 20c of the emergency apply valve 20 via the park line 18 and the park valve 22. The pressure at the control input 20c moves the emergency apply valve 20 to its first position and the trailer reservoir 28 is thus connected to the spring brake chamber 23a via the emergency apply line 16, the emergency apply valve 20 and the spring brake line 21. The resulting flow of pressurised fluid to the spring brake chamber 23a results in the release of the spring brake. The spring brake can be reapplied by returning the shunt valve 14 to its first position.

To avoid damage to the brake or brake actuator due to the simultaneous application of the spring brake and the service brake (compounding of the brakes), the EBS control valve assembly 25 may also include a further double check valve in a line connecting the second portion 21b of the spring brake line 21 to the delivery port of the modulator or one of the modulators in the EBS control valve assembly 25. This double check valve is configured such that no flow of fluid along this line is permitted unless, when the spring brake chamber 23a is exhausted (and so the spring brake applied), there is demand for service braking. Then, there is flow of pressurised fluid to the spring brake chamber 23a (to release the spring brake) in addition to flow to the service braking chamber 23b.

A second embodiment of the invention is illustrated in Figure 6. This is very similar to the embodiment of the invention discussed above and illustrated in Figures 1 to 5, and differs only in the elements described below. Specifically, the difference resides in the configuration of the emergency braking override valve 36' which, in the second embodiment of the invention has only a first port 36a', which is connected to the output port 22b of the park valve 22, and a second port 36b' which is connected to the control input 20c of the emergency apply valve 20.

The emergency braking override valve 36' is movable between a first position (illustrated in Figure 6) in which its first port 36a' is connected to its second port 36b', and a second position in (illustrated in Figure 7) in which flow of fluid between its second port 36b' and its first port 36a' is substantially prevented. Again, the passage of fluid from the supply line 16 to the control input 20c of the emergency apply valve 20 via the park valve 22 is therefore not affected by the emergency braking override valve 36' when the emergency braking override valve 36' is in its first position. This embodiment of emergency braking override valve 36' is also electrically operable, in this example, by means of a solenoid 36d', and mechanical biasing means (in this example a spring) is provided to urge the emergency braking override valve 36' into its first position. Movement of the emergency braking override valve 36' from the first position to the second position is achieved by the supply of an electrical current to the solenoid 36d.

The braking system according to the second embodiment of the invention operates in exactly the same way as the first embodiment of braking system described above in all respects other than when suppression of the emergency application of the spring brake due to loss of pressure in the supply line 12 is required as described below. The second embodiment of braking system is shown in normal service braking mode in Figure 6.

Again, if it is deemed desirable to allow emergency application of the vehicle spring brakes to take place, and if there is no problem with the electrical power supply to the system 10, the system 10 can be operated to prevent this by the supply of electrical power to the solenoid 36d' of the emergency braking override valve 36'. This causes the emergency braking override valve 36' to move to its second position wherein the control input 20c of the emergency apply valve 20 is isolated from the remainder of the system, as illustrated in Figure 7.

Provided this is done before the pressure at the control input 20c of the emergency apply valve 20 drops too low to overcome the biasing force of the biasing means, movement of the emergency apply valve 20 to its second position, and the resulting venting of the spring brake chamber 23a is prevented. As with the first embodiment of the invention, emergency braking can then, if desired, be effected using the service brake by the supply of electrical power to the solenoid 32d of the brake apply valve 32. Just as described above in relation to Figure 2, this causes the brake apply valve 32 to move to its second position in which the first input 32a is closed and the second input 32c is connected to the output 32b. In this case however, pressurised fluid passes from the reservoir 28 to the EBS control valve assembly 25 via the brake apply valve 32 and the service brake line 27 to effect service braking. As with conventional service braking, the EBS valve assembly can use conventional ABS control algorithms to modify the emergency braking in accordance with standard anti-lock control procedures if wheel slip is detected.

The ECU is preferably programmed to activate the emergency braking override valve 36' to override the emergency application of the spring brake whenever a sudden drop in the pressure is detected by pressure sensor 40 at the output port 22b of the park valve 22, or when the pressure detected by this pressure sensor 40 falls below a predetermined level. The ECU may, however, be programmed to energise the emergency braking override valve 36' to override the emergency application of the spring brake when a sudden drop in the pressure at sensor 40 is detected, or when this pressure falls below a predetermined level, but only if certain other predetermined criteria are met – if the vehicle speed exceeds a predetermined level, or if the fluid pressure in the trailer reservoir 28 exceeds a predetermined level, for example.

The pressurised fluid used in the invention is preferably compressed air, but any other fluid may be used instead, and the invention could equally be employed in a hydraulic braking system.

When used in this specification and claims, the term “line” covers any type of conduit for pressurised fluid including a passage or bore through a housing, a hose, pipe or tube. It should also be appreciated that, whilst in this example, only one brake actuator 23 is shown, the spring brake line 21 and the EBS valve assembly 25 may be connected to more than one brake actuator. The system 10 may also be provided with more than one EBS valve assembly 25. For example, one EBS valve assembly 25 may be connected to one or more actuators on one side of the trailer, which a second EBS valve assembly is connected to one or more actuators on the other side of the trailer, with both EBS valve assemblies being connected to the service brake line 27.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A vehicle braking system comprising a brake actuator which is operable to adopt a brake apply position in which the actuator may apply a braking force to a vehicle wheel and a brake release position in which the actuator may release any braking force applied to a vehicle wheel, the brake actuator having a spring brake chamber and a spring and being configured such that supply of pressurised fluid to the spring brake chamber causes the brake actuator to move against the biasing force of the spring to the brake release position and release of pressurised fluid from the spring brake chamber causes the brake actuator to move under the action of the spring to the brake apply position, the system further including a supply line whereby the spring brake chamber is, in use, connected to a supply of pressurised fluid, and an emergency brake apply valve which has a control port which is connected to the supply line, the emergency brake apply valve being configured automatically to connect the spring brake chamber to a low pressure region when the pressure at the control port falls below a predetermined level, wherein the system further includes an electrically operable emergency braking override valve which has a first port which is connected to the supply line and a second port which is connected to the control port of the emergency brake apply valve and which, when supplied with sufficient electrical power, acts to prevent loss of fluid pressure at the control port of the emergency brake apply valve.

2. A vehicle braking system according to claim 1 wherein the emergency brake apply valve has an input port which is connected to the supply line and a second port which is connected to the spring brake chamber, and is movable between a first position in which the input port is connected to the output port and a second position in which the input port is closed and the output port vents to a low pressure region.

3. A vehicle braking system according to claim 2 wherein mechanical biasing means is provided to urge the emergency brake apply valve into the

second position, and movement of the emergency brake apply valve from the second position to the first position is achieved by the supply of pressurised fluid to the control input at sufficient pressure to overcome the force of the biasing means.

4. A vehicle braking system according to any preceding claim wherein the brake actuator further includes a service brake chamber, wherein supply of pressurised fluid to the service brake chamber causes the brake actuator to move to the brake apply position.

5. A vehicle braking system according to claim 4 further including a control line which in use connects a source of a fluid pressure braking demand signal to the service brake chamber via a braking control valve assembly.

6. A vehicle braking system according to claim 5 wherein the brake valve assembly comprises at least one modulator which has a control port which is connected to the control line for receipt of a fluid pressure braking demand signal, a supply port which is connected to a source of pressurised fluid, a delivery port which is connected to the service brake chamber, and an exhaust port which vents to a low pressure region, the modulator being operable to move between a build configuration in which the supply port is connected to the delivery port whilst the exhaust port is closed, a hold configuration in which the exhaust port and the supply ports are closed and an exhaust configuration in which the delivery port is connected to the exhaust port whilst the supply port is closed.

7. A vehicle braking system according to claim 5 or 6 wherein the vehicle braking system further comprises a pressurised fluid reservoir which is connected to the control line via a brake apply valve.

8. A vehicle braking system according to claim 7 wherein the brake apply valve is movable between a first configuration in which the brake apply valve substantially prevents flow of fluid from the pressurised fluid reservoir to the

control line, and a second in which the brake apply valve allows flow of fluid from the pressurised fluid reservoir to the control line.

9. A vehicle braking system according to claim 5 wherein a non-return valve is provided in the supply line upstream of the input port of the emergency brake apply valve, the non-return valve permitting flow of fluid along the supply line to the emergency brake apply valve whilst substantially preventing flow of fluid in the opposite direction.

10. A vehicle braking system according to claims 7 and 9 wherein the pressurised fluid reservoir is connected to the supply line downstream of the non-return valve.

11. A vehicle braking system according to claims 9 and 10 wherein a second non-return valve is provided in the supply line upstream of the input port of the emergency brake apply valve, the second non-return valve also permitting flow of fluid along the supply line to the emergency brake apply valve whilst substantially preventing flow of fluid in the opposite direction.

12. A vehicle braking system according to claim 11 wherein the pressurised fluid reservoir is connected to the supply line between the two non-return valves.

13. A vehicle braking system according to one of claims 2 to 12 wherein the emergency braking override valve has a third port which is connected to the supply line between the first port of the emergency brake apply valve and the connection to the control port of the emergency brake apply valve.

14. A vehicle braking system according to claims 9 and 13 wherein the third port is connected to the supply line downstream of the non-return valve.

15. A vehicle braking system according to claims 11 and 13 wherein the third port is connected to the supply line between the two non-return valves.

16. A vehicle braking system according to any of claims 13 to 15 wherein the emergency braking override valve is movable between a first position in which its first port is connected to its second port, whilst its third port is closed, and a second position in which its third port is connected to its second port whilst its first port is closed.

17. A vehicle braking system according to claim 16 wherein the emergency braking override valve is provided with mechanical biasing means to urge the emergency braking override valve into the first position, movement of the emergency braking override valve from the first position to the second position being achieved by the supply of electrical power to the emergency braking override valve.

18. A vehicle braking system according to any one of claims 1 to 12 wherein the emergency braking override valve is movable between a first position in which its first port is connected to its second port, and a second position in which flow of fluid between its second port and its first port is substantially prevented.

19. A vehicle braking system according to claim 18 wherein the emergency braking override valve is provided with mechanical biasing means to urge the emergency braking override valve into its first position, and movement of the emergency braking override valve from the first position to the second position being achieved by the supply of an electrical current to the emergency braking override valve.

20. A vehicle braking system substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

21. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.

Figure 1

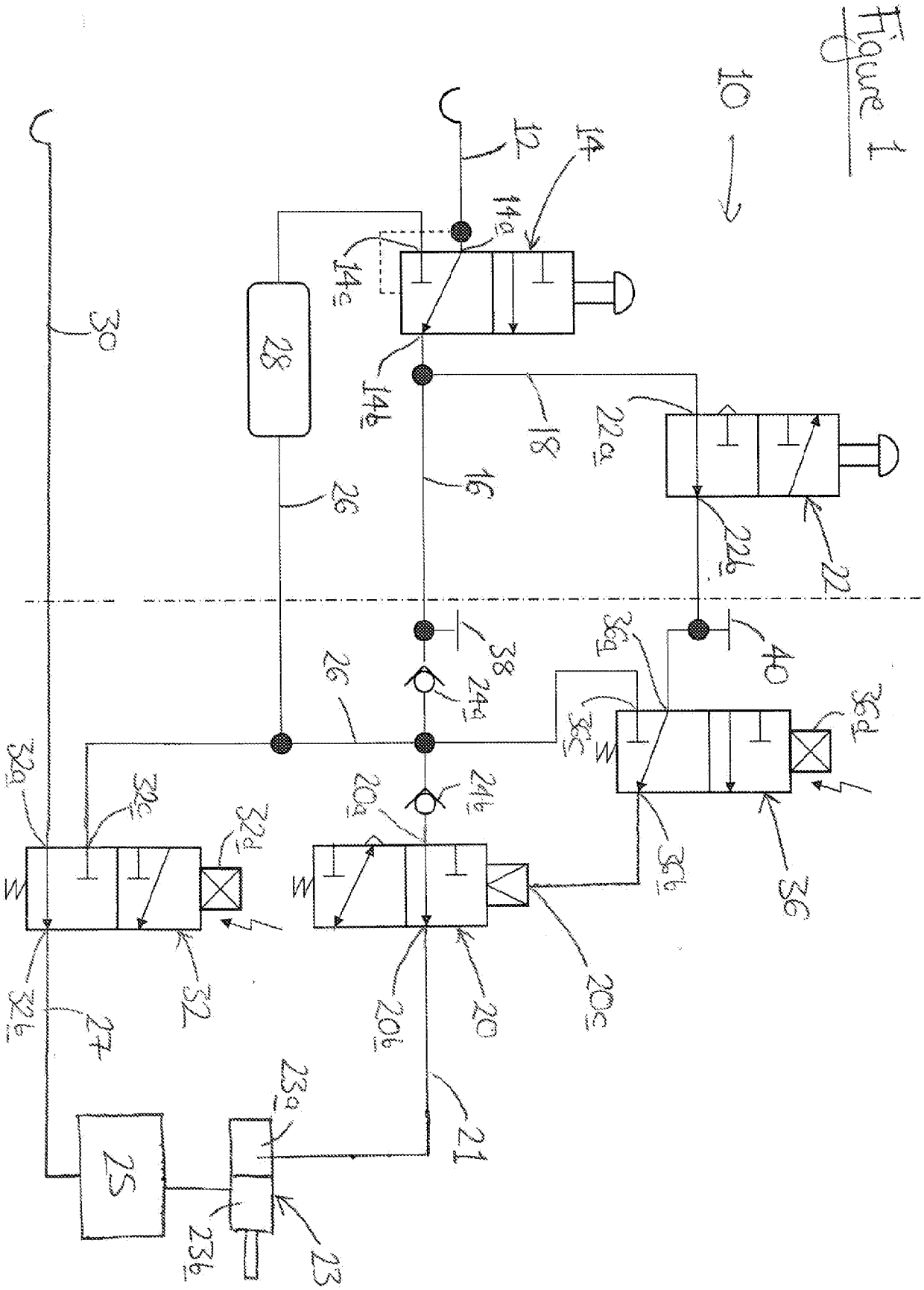

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Figure 2

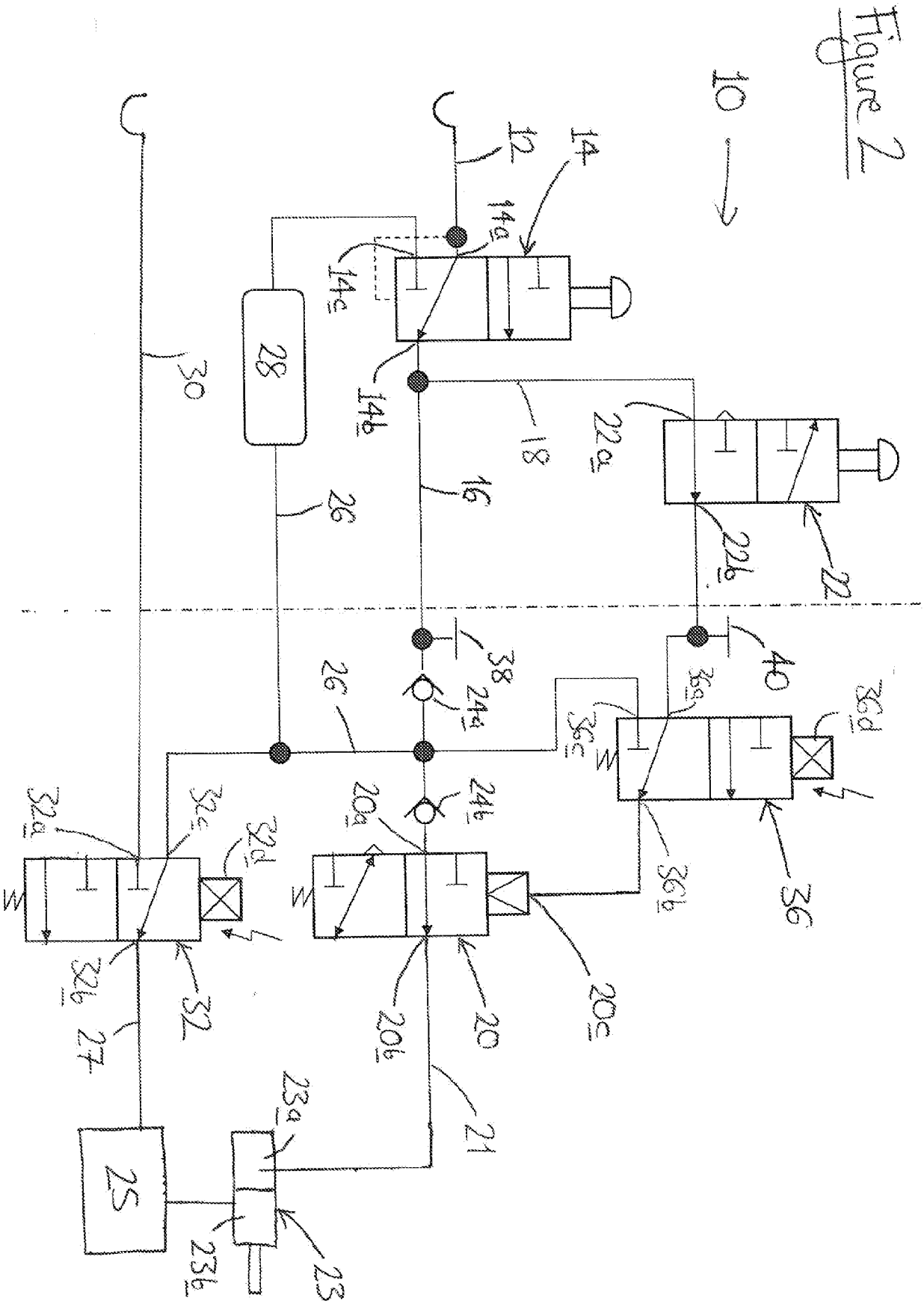

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Figure 3

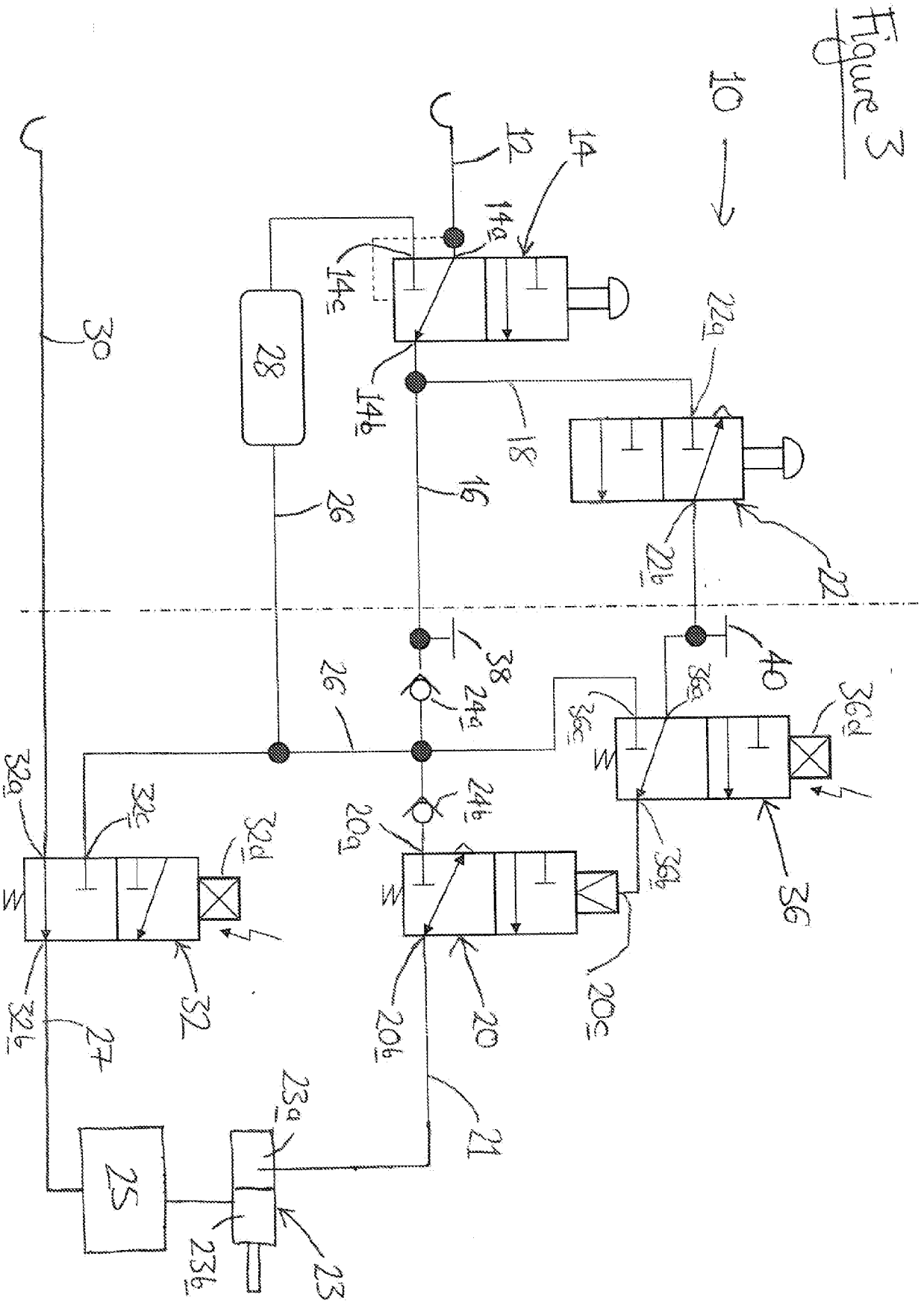

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Figure 4

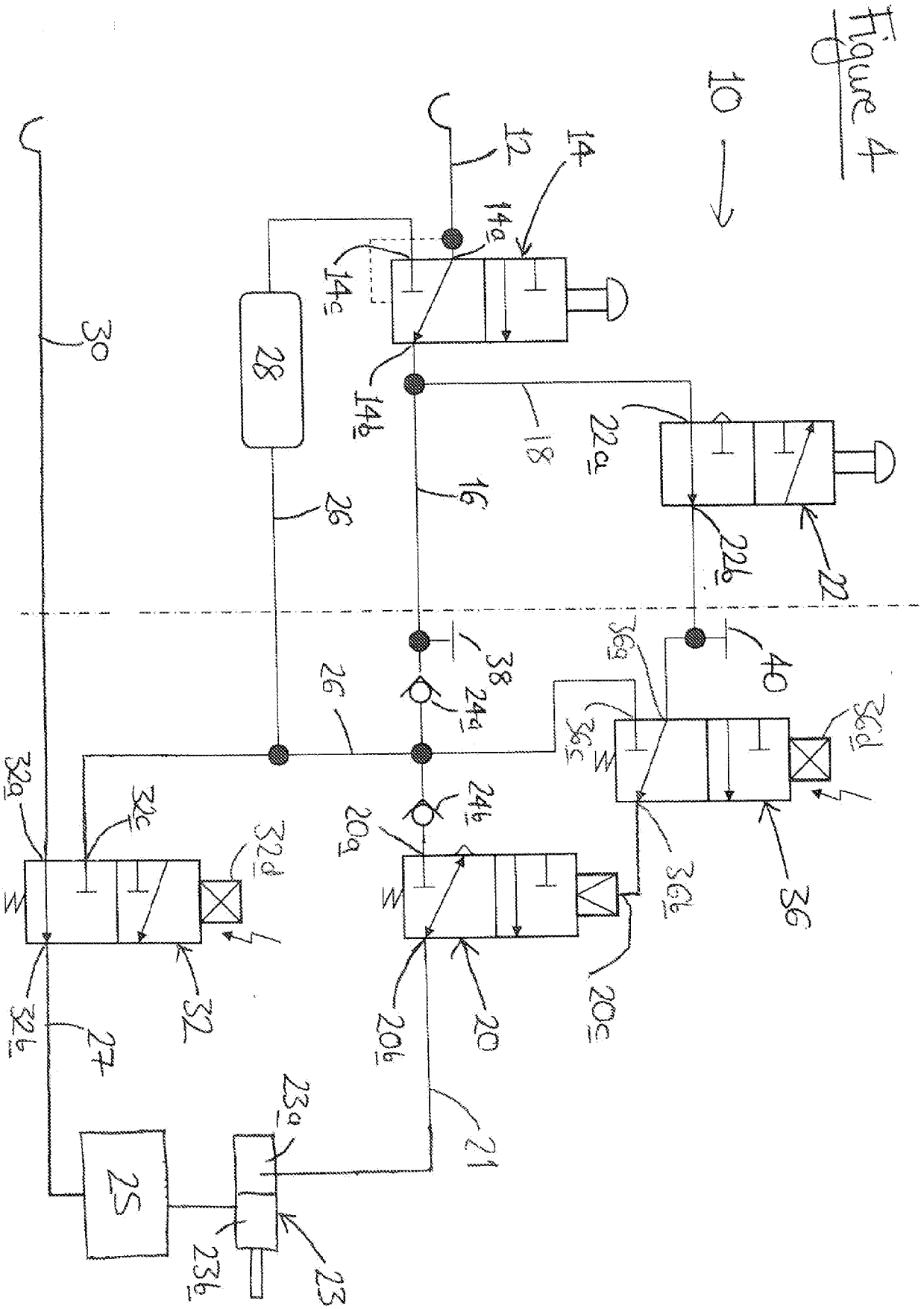

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Figure 5

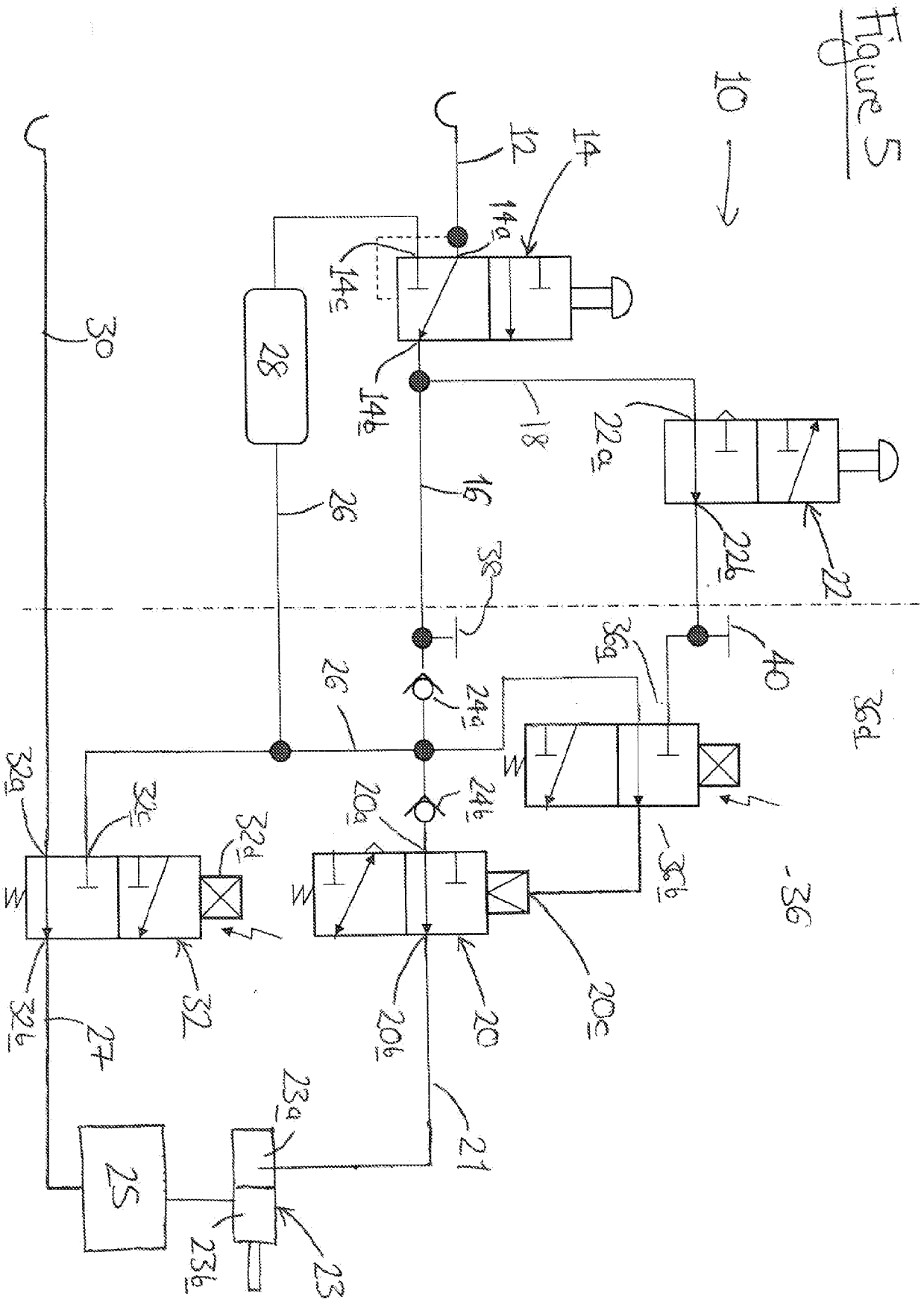

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Figure 6

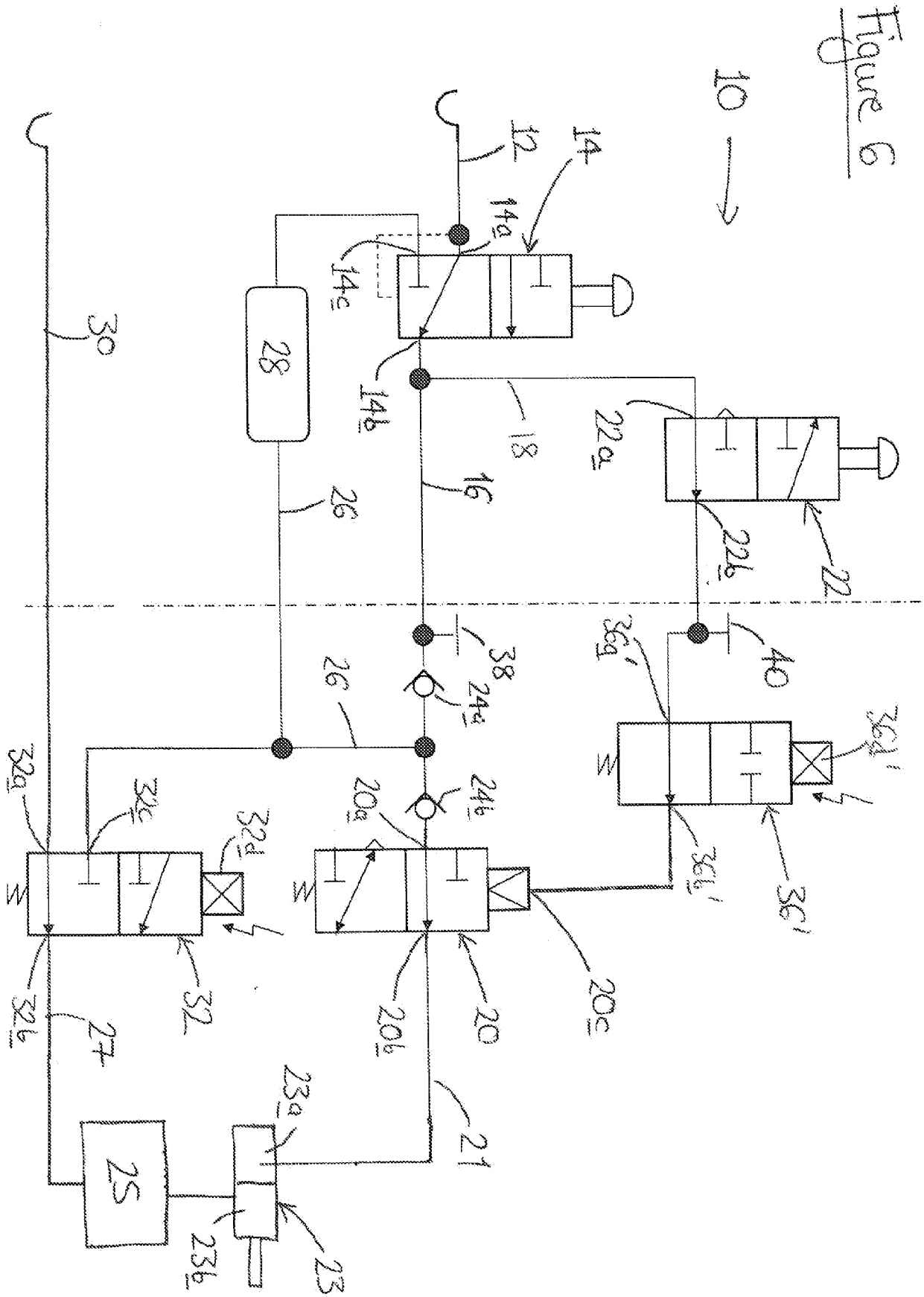
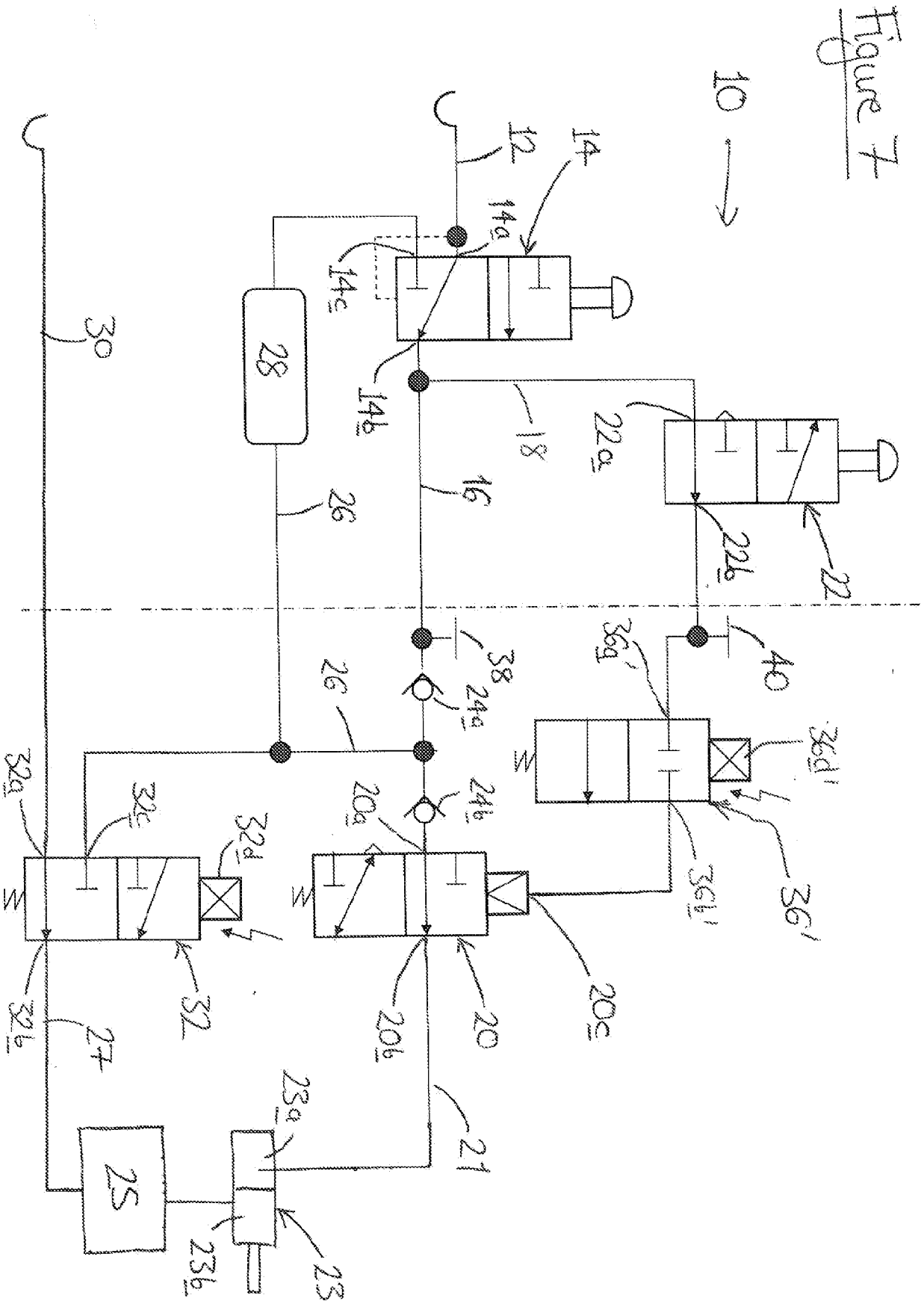

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Figure 7


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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/050659

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60T13/26 B60T8/17
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/003491 A1 (WABCO GMBH [DE]; RISSE RAINER [DE]; STENDER AXEL [DE]) 13 January 2011 (2011-01-13) cited in the application page 8, line 11 - page 9, line 13; figures 1-4	1-21
A	DE 201 22 779 U1 (WABCO GMBH [DE]) 30 August 2007 (2007-08-30) paragraph [0065] - paragraph [0077]; figures 1-5 paragraph [0108] - paragraph [0124]; figures 1-5	1-21
A	EP 2 058 193 A2 (HALDEX BRAKE PROD GMBH [DE]) 13 May 2009 (2009-05-13) paragraph [0035] - paragraph [0038]; figures 1,2	1-21

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 November 2012	20/11/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schroeder, Rainer

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2012/050659

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP 2058193 A2	13-05-2009	DE 102007053765 A1	20-05-2009
		EP 2058193 A2	13-05-2009