(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) **EP 4 530 468 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.04.2025 Bulletin 2025/14

(21) Application number: **24187507.9**

(22) Date of filing: **09.07.2024**

(51) International Patent Classification (IPC):
F04B 49/00 *(2006.01)* ***F15B 11/17*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04B 49/002; F15B 11/0423; F15B 11/0426; F15B 11/17; F15B 2211/20538; F15B 2211/20546; F15B 2211/20576; F15B 2211/2654; F15B 2211/2656; F15B 2211/50536; F15B 2211/528; F15B 2211/635

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **10.07.2023 IT 202300014379**

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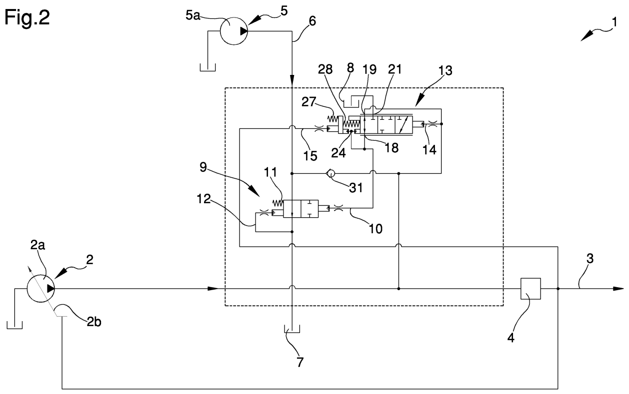
Remarks:
Claims 16 - 21 are deemed to be abandoned due to non-payment of the claims fees (Rule 45(3) EPC).

(54) **CIRCUIT FOR THE FLOW RATE CONTROL IN A HYDRAULIC CIRCUIT**

(57) The circuit for the flow rate control in a hydraulic circuit, comprises:
main pumping means (2) with variable displacement; a delivery line (3) connected to said the pump and along which at least one user point (4) is arranged; auxiliary pumping means (5) comprising at least one auxiliary pump (5a); an auxiliary supply line (6) connected to the auxiliary pump (5a) and to the delivery line (3); one discharge tank (7, 8); valve means (9, 13) operable to set in communication/isolate the auxiliary pumping means (5) with/from the tank (7, 8);
wherein the valve means (9, 13) comprise first valve means (9) movable between at least a discharge position and a supply position, at least one first driving line (10) of the first valve means (9), and comprise second valve means (13) operable between at least a first working position and a second working position, at least a second driving line (14) and a third driving line (15) being provided operating from opposite sides on the second valve means (13), wherein the second driving line (14) and the third driving line (15) communicates with the delivery line (3) from opposite sides of the user point (4), the second valve means (13) displacing to the first working position as a result of the attainment of a first predefined pressure difference between the second driving line (14) and the third driving line (15) and displacing to the second working position as a result of the attainment of a second predefined pressure difference between the second driving line (14) and the third driving line (15).

Fig.2



EP 4 530 468 A1

Description

Technical Field

[0001] The present invention relates to a circuit for the flow rate control in a hydraulic circuit.

Background Art

[0002] To supply the hydraulic circuits of a vehicle, it is known to use a variable displacement main pump adapted to send a working fluid under pressure along a delivery line (connected to a hydraulic circuit) and adjustment means for adjusting the displacement (compensating element) of the main pump so as to keep substantially constant the pressure drop at the ends of a user point (generally identified as a variable displacement choke) located along the delivery line regardless of the load, i.e., of the flow rate required by the hydraulic circuit.

[0003] More specifically, the adjustment means of the displacement comprise a command actuator which operates the displacement of the main pump, provided with a thrust chamber adapted to command the operation thereof and with valve means that, depending on the pressure difference at the ends of the choke, are adapted to supply the thrust chamber with the working fluid under pressure so as to reduce the displacement of the main pump or to set the thrust chamber in communication with a discharge tank to increase the pump displacement.

[0004] In other words, the valve means are calibrated in such a way that, when the pressure difference at the ends of the user point exceeds the calibration value, the thrust chamber is supplied with the working fluid under pressure so as to reduce the displacement of the main pump and, consequently, also the pressure difference at the ends of the user point. Similarly, when the pressure difference at the ends of the user point drops below the calibration value, the thrust chamber is set in communication with the discharge tank so as to increase the displacement of the main pump and, consequently, also the pressure difference at the ends of the user point.

[0005] This solution has some drawbacks in that, when faced with an increase in the flow rate demand from the user point that would correspond to a greater displacement than the maximum displacement of the main pump, the latter is no longer able to increase its own displacement and, consequently, the pressure difference at the ends of the user point drops, as it can no longer be maintained.

[0006] To overcome the drawbacks of the solution described above, the use is known of an auxiliary pump adapted to assist the operation of the variable displacement main pump. Such an auxiliary pump can be of the fixed displacement type or of the variable displacement type.

[0007] In the first case (Figure 1A) wherein the auxiliary pump is of the fixed displacement type, it happens that, when the required flow rate is slightly higher than the maximum flow rate which can be delivered by the main pump, once the working fluid along the delivery line has reached the pressure required by the user point, almost all of the flow rate delivered by the auxiliary pump is sent to the discharge tank, thus dissipating a high amount of energy and resources. In this embodiment, valve means are provided which are adapted to set in communication/isolate the auxiliary pump with/from the delivery line and provided with a spring, the calibration value of which defines the pressure difference at the ends of the user point beyond which the auxiliary pump is connected to the discharge tank.

[0008] This solution also has some drawbacks since the pressure difference at the ends of the user point is no longer the initial design pressure but lower and equal to the spring calibration of the valve means.

[0009] Still another drawback consists in the fact that the valve means modulate almost continuously when the auxiliary pump is choked towards the discharge tank, resulting in increased noise.

[0010] In the second case (Figure 1B), on the other hand, wherein the auxiliary pump is of the variable displacement type, valve means are provided to set the auxiliary pump in communication with the delivery line when the pressure difference at the ends of the user point drops below a predefined value that is lower than the calibration value of the main pump compensator. This implies that the instant when the auxiliary pump begins to supply the working fluid under pressure along the delivery line, the pressure difference at the ends of the user point increases to the calibration value of the auxiliary pump compensator, which must necessarily be lower than that of the main pump compensator. Thus, in this case, too, it turns out that the pressure difference at the ends of the user point is lower than the initial design pressure difference.

Description of the Invention

[0011] The main aim of the present invention is to devise a circuit for the flow rate control in a hydraulic circuit providing for the use of a main pump and of an auxiliary pump and which allows optimizing the operation thereof while minimizing energy dissipation.

[0012] Within this aim, one object of the present invention is to devise a circuit for the flow rate control in a hydraulic circuit which allows maintaining the pressure difference at the ends of the user point which is located along the delivery line at the design value under any operating condition, that is, regardless of whether or not the auxiliary pump also comes into operation.

[0013] Yet another object of the present invention is to devise a circuit that is characterized by more stable operation than the solutions known to date and described above.

[0014] Another object of the present invention is to devise a circuit for the flow rate control in a hydraulic circuit which allows the aforementioned drawbacks of the prior art to be overcome within the framework of a simple, rational, easy and effective to use as well as cost-effective solution.

[0015] The aforementioned objects are achieved by this circuit for flow rate control in a hydraulic circuit according to claim 1.

Brief Description of the Drawings

[0016] Other characteristics and advantages of the present invention will become more apparent from the description of a preferred, but not exclusive, embodiment of a circuit for the flow rate control in a hydraulic circuit, illustrated by way of an indicative, yet non-limiting example in the accompanying tables of drawings in which:

- Figures 1A and 1B represent the hydraulic diagrams of two circuits for the flow rate control in a hydraulic circuit of known type;
- Figure 2 is a representation of the hydraulic diagram of a circuit according to the invention, in a first embodiment;
- Figure 3 is a representation of the hydraulic diagram of a circuit according to the invention, in a second embodiment;
- Figure 4 is a representation of the hydraulic diagram of a circuit according to the invention, in a third embodiment;
- Figure 5 is a representation of the hydraulic diagram of a circuit according to the invention, in a fourth embodiment;
- Figure 6 is a representation of the hydraulic diagram in Figure 4 with the second valve means shown in cross section.

Embodiments of the Invention

[0017] With particular reference to these figures, reference numeral 1 globally denotes a circuit for the flow rate control in a hydraulic circuit.

[0018] The circuit 1 comprises main pumping means 2 comprising at least one main pump 2a with variable displacement, a delivery line 3 connected to the main pump 2a in a fluid-operated manner and connectable to the hydraulic circuit of a vehicle (not shown in the figures), where at least one user point 4 is arranged along the delivery line 3 (frequently represented in the hydraulic diagrams as a variable flow rate choke).

[0019] Appropriately, the main pumping means 2 comprise a main control line 2b adapted to adjust the displacement of the main pump 2a and connected to the delivery line 3 in a fluid-operated manner, downstream of the user point 4.

[0020] The circuit 1 then comprises auxiliary pumping means 5 comprising at least one auxiliary pump 5a, an auxiliary supply line 6 connected in a fluid-operated manner to the auxiliary pump 5a and to the delivery line 3, at least one discharge tank 7, 8 and valve means 9,13 operable to set the auxiliary pumping means 5 in communication with/isolate from the tank 7, 8.

[0021] In the preferred, but not exclusive, embodiments shown in the figures, the circuit 1 comprises a first tank 7 and a second tank 8. The first tank and the second tank 7 and 8 can be either separate from each other, as in the embodiments shown in the figures, or coincident with each other. In the remainder of this description, therefore, reference will be made to the presence of two separate tanks, although it cannot be ruled out that the circuit 1 may comprise a single discharge tank.

[0022] According to the invention, the valve means 9,13, comprise first valve means 9 movable between at least a discharge position, wherein they set the auxiliary pumping means 5 in communication with the first tank 7, and a supply position, wherein they isolate the auxiliary pumping means 5 from the first tank 7 and at least a first driving line 10 of the first valve means 9. Specifically, the first driving line 10 operates on one side of the first valve means 9 and is counteracted, on the opposite side, by the elastic return means 11 and by an additional driving line 12 communicating with the first tank 7.

[0023] Advantageously, the auxiliary pump 5a can be of the fixed displacement type, as in the embodiments shown in Figures 2 and 4 or, alternatively, of the variable displacement type, as in the embodiments shown in Figures 3 and 5.

[0024] In the first case, wherein the auxiliary pump 5a is of the fixed displacement type, the first valve means 9 are adapted to set the auxiliary supply line 6 in communication with the first tank 7 in the discharge position and to isolate said auxiliary supply line 6 from the first tank 7 in the supply position. Therefore, in the discharge position, the working fluid delivered by the auxiliary pump 5a is sent into the first tank 7 while, in the supply position, it flows out along the delivery line 3.

[0025] In the second case, the auxiliary pumping means 5 comprise an auxiliary control line 5b adapted to adjust the displacement thereof. In this embodiment, the first valve means 9 are adapted to set the auxiliary control line 5b in communication with the first tank 7 in the discharge position, so as to reduce the displacement of the auxiliary pump 5a, and to set the auxiliary control line 5b in communication with the auxiliary supply line 6 in the supply position, so as to increase the displacement of the auxiliary pump 5a.

[0026] In other words, when the first valve means 9 are in the discharge position, the contribution of the auxiliary pump 5a is substantially nil while, in the supply position, the auxiliary pump 5a contributes to increasing the flow rate of the working fluid along the discharge line 3.

[0027] Still according to the invention, the valve means 9,13 comprise second valve means 13 operable between at least a first working position, wherein they set the first driving line 10 in communication with one of either the second tank 8 or a source of the working fluid under pressure, so as to bring the first valve means 9 to the supply position, and a second working position, wherein they set the first driving line 10 in communication with the other of either the second tank 8 or the source of the working fluid under pressure, so as to bring the first valve means 9 to the discharge position. In the embodiments shown in the figures, the source of the working fluid under pressure is the delivery line 3, which is connected with the second valve means 13 upstream of the user point 4.

[0028] In other words, when the second valve means 13 are in the first working position, the first valve means 9 are in the supply position while, when the second valve means 13 reach the second working position, the first valve means 9 are in the discharge position.

[0029] The circuit 1 also comprises at least a second driving line 14 and a third driving line 15 operating from opposite sides on the second valve means 13, wherein the second driving line 14 communicates with the delivery line 3 upstream of the user point 4 and the third driving line 15 communicates with the delivery line 3 downstream of the user point 4 (wherein the terms "upstream" and "downstream" used herein refer to the direction of flow of the working fluid delivered by the main pump 2a along the delivery line 3. The second valve means 13 then move to the first working position as a result of the attainment of a first predefined pressure difference between the second driving line 14 and the third driving line 15 and move to the second working position as a result of the attainment of a second predefined pressure difference between the second driving line 14 and the third driving line 15.

[0030] Advantageously, as shown in Figure 6, the second valve means 13 comprise at least one hollow body 16 defining a housing seat 17 provided with at least a first port 18 communicating with the first driving line 10, with at least a second port 19 communicating with the source of the working fluid under pressure, with at least a third port 20 communicating with the third driving line 15 and with at least a fourth port 21 communicating with the second tank 8. More particularly, the second valve means 13 then comprise at least a first distributor element 22 and a second distributor element 23 housed within the housing seat 17 in a sliding manner and mechanically connected to each other.

[0031] Appropriately, between the distributor elements 22 and 23 is defined a first chamber 24, between the first distributor element 22 and the body 16 is defined a second chamber 25 communicating with the second driving line 14, upstream of the user point 4, and between the second distributor element 23 and the body 16 is defined a third chamber 26 communicating with the third port 20. In the special, but not exclusive, embodiments shown in the figures, the second chamber 25 communicates with the second port 19.

[0032] The distributor elements 22 and 23 are adapted, as a result of their displacement within the housing seat 17 to set in communication/isolate the first chamber 24 and the first port 18 with/from the second port 19 and the fourth port 21.

[0033] Advantageously, the active areas facing the first chamber 24 are equal to or greater than the useful section of the second driving line 14 and of the third driving line 15.

[0034] In more detail, the distributor elements 22 and 23 and, in particular, the first distributor element 22, are conformed so as to open and close the connections between the various ports/chambers. In particular, the distributor elements 22 and 23 are adapted to set at least one of either the first chamber 24 or the first port 18 in communication with the second port 19, isolating it from the fourth port 21, and to set at least one of either the first chamber 24 or the first port 18 in communication with the fourth port 21, isolating it from the second port 19.

[0035] Preferably, the second valve means 13 comprise first elastic means 27 housed within the third chamber 26 and operating on the second distributor element 23. On the second distributor element 23 then operate the third driving line 15 and the first elastic means 27.

[0036] Additionally, the second valve means 13 also comprise second elastic means 28 housed within the first chamber 24.

[0037] More particularly, the second elastic means 28 are adapted to expand when, as a result of the displacement of the distributor elements 22 and 23, the first chamber 24 is set in communication with the second port 19, pressurizing, and they are adapted to compress when, as a result of the displacement of the distributor elements 22 and 23, the first chamber 24 is set in communication with the fourth port 21, depressurizing.

[0038] As anticipated above, the first distributor element 22 and the second distributor element 23 are mechanically connected to each other. More specifically, the first distributor element 22 has a first abutment surface 29a adapted to interact with a first stopping surface 29b defined by the second distributor element 23 as a result of the pressurization of the first chamber 24, and it has a second abutment surface 30a adapted to interact with a second stopping surface 30b defined by the second distributor element 23 as a result of the discharge connection (and thus the consequent depressurization) of the first chamber 24.

[0039] Thus, the first distributor element 22 and the second distributor element 23 move synchronously with each other during the displacements between the first working position and the second working position, as a result of the interaction between the abutment surfaces 29a, 30a and the respective stopping surfaces 29b, 30b, while the first distributor element 22 moves with respect to the second distributor element 23 when the first chamber 24 is set in communication with the fourth port 21 and isolated from the second port 19, as a result of the discharge connection (and thus of the consequent depressurization) of the first chamber 24, and when the first chamber 24 is set in communication with the second port 19 and isolated from the fourth port 21, as a result of the pressurization of the first chamber 24.

[0040] In the embodiments shown in Figures 2 and 3, in the first working position, the second valve means 13 set the first driving line 10 in communication with the second port 19 (and thus with the source of the working fluid under pressure) and, in the second working position, they set the first driving line 10 in communication with the second tank 8. In these embodiments, the first chamber 24 communicates with the first port 18 regardless of the position of the distributor elements 22 and 23. Therefore, in the first working position, the first port 18 is set in communication with the second port 19, so as to pressurize the first driving line 10 and, in the second working position, the first port 18 is set in communication with the fourth port 21 (and thus with the second tank 8) so as to depressurize the first driving line 10. The first predefined pressure difference, as a result of which the distributor elements 22 and 23 move to set the first driving line 10 in communication with the second tank 8, is greater than the second predefined pressure difference as a result of which the distributor elements 22 and 23 move to set first driving line 10 in communication with second port 19. The first valve means 9 are arranged in the home condition, i.e., when there is no pressure along the first driving line 10, in the discharge position and move to the supply position when the second valve means 13 reach the first working position. In other words, when the first driving line 10 is pressurized, the first valve means 9 are arranged in the supply position while, when the first driving line 10 is depressurized, the first valve means 9 are arranged in the discharge position.

[0041] In these embodiments, the auxiliary pump 5a therefore starts its operation as a result of the change in state of the first valve means 9 which, as a result of the pressure along the first driving line 10 connected to the first port 18, move to the supply position thus interrupting the outflow of the working fluid delivered by the auxiliary pump itself to the first tank 7 and thus diverting the flow rate along the delivery line 3, upstream of the user point 4, passing through the one-way valve 31.

[0042] At the moment when the first valve means 9, as a result of the connection of the first chamber 24 (and thus of the first driving line 10) with the second tank 8, and of the action of the elastic return means 11, return to the discharge position, the auxiliary pump 5a is instead disconnected.

[0043] In the embodiments shown in Figures 4, 5, and 6, on the other hand, in the first working position, the second valve means 13 set the first driving line 10 in communication with the second tank 8 and, in the second working position, they set the first driving line 10 in communication with the second port 19 (and thus with the source of the working fluid under pressure). In these embodiments, the first chamber 24 is separate from the first port 18.

[0044] In addition, the fourth port 21 is positioned between the first chamber 24 and the first port 18. In these embodiments, the first predefined pressure difference, as a result of which the distributor elements 22 and 23 move to set the first driving line 10 in communication with the second port 19, is greater than the second predefined pressure difference as a result of which the distributor elements 22 and 23 move to set the first driving line 10 in communication with the second tank 8. The first valve means 9 are arranged in the home condition, i.e., in the absence of pressure along the first driving line 10, in the supply position, and move to the discharge position when the second valve means 13 reach the second working position, i.e., as a result of the pressurization of the first driving line 10.

[0045] Thus, in these embodiments, the auxiliary pump 5a starts its operation when the first driving line 10 is connected to the second discharge tank 8, while the auxiliary pump 5a disconnects from the delivery line 3 at the moment when the first valve means 9 change state as a result of the connection of the first driving line 10 with the second port 19.

[0046] Appropriately, in the embodiments shown in Figures 4, 5 and 6, the first chamber 24 is set in communication with the fourth port 21 in the second working position and the first chamber 24 is set in communication with the second port 19 in the first working position.

[0047] In addition, the second port 19 is set in communication with the first port 18 in the second working position and the first port 18 is set in communication with the fourth port 21 in the first working position.

[0048] In more detail, in the embodiments shown in Figures 4, 5 and 6, the first distributor element 22 and the second distributor element 23 move synchronously with each other from the first working position towards the second working position counteracting the first elastic means 27, with the first abutment surface 29a resting on the first stopping surface 29b and from the second working position towards the first working position, with the second abutment surface 30a resting on the second stopping surface 30b. The first distributor element 22 then moves with respect to the second distributor element 23 when the first chamber 24 is set in communication with the fourth port 21 and isolated from the second port 19, as a result of the compression of the second elastic means 28, and when the first chamber 24 is set in communication with the second port 19 and isolated from the fourth port 21, as a result of the extension of the second elastic means 28.

[0049] Appropriately, as a result of the displacement of the first distributor element 22 with respect to the second distributor element 23 when the first chamber 24 is set in communication with the fourth port 21 and isolated from the second port 19, the first port 18 is isolated from the fourth port 21 and set in communication with the second port 19, consequently pressurizing the first driving line 10 so as to command the change in state of the first valve means 9 from the supply position to the discharge position. Similarly, as a result of the displacement of the first distributor element 22 with respect to the second distributor element 23 when the first chamber 24 is set in communication with the second port 19, the connection between the first port 18 and the fourth port 21 opens, so as to set the first driving line 10 in communication with the second tank 8 and cause the change in state of the first valve means 9, which thus return to the supply position.

[0050] In all the described embodiments shown, the distributor elements 22 and 23 move counteracting the first elastic means 27 from the first working position towards the second working position as a result of the increase in the pressure difference between the second driving line 14 and the third driving line 15, while moving from the second working position to the first working position as a result of the decrease in the pressure difference between the second driving line 14 and the third driving line 15.

[0051] The preload of the first elastic means 27, related to the active areas of the driving lines 14 and 15, at the position close to the distributor elements 22 and 23 (i.e., when the surfaces 30a and 30b are in contact with each other), at the position of the first distributor element 22 which sets the second port 19 in communication with the first chamber 24, defines a first calibration value.

[0052] This first calibration value defines the pressure difference at the ends of the user point 4 upon reaching which the auxiliary pump 5a starts to operate.

[0053] The whole flow rate delivered by the auxiliary pump 5a is then added to the flow rate delivered by the main pump 2a which, in the meantime is choked by the relevant displacement compensating element, so as to reach its calibration value (which is intermediate between the first calibration value and the second calibration value of the circuit 1).

[0054] The preload of the first elastic means 27, related to the active areas of the driving lines 14 and 15, at the extended position of the distributor elements 22 and 23 (i.e., when the surfaces 29a and 29b are in contact with each other), at the position of the first distributor element 22 which sets the second tank 8 in communication with the first chamber 24, defines a second calibration value.

[0055] This second calibration value defines the pressure difference at the ends of the user point 4 upon reaching which the auxiliary pump 5a is disconnected.

[0056] The user point 4 is now supplied only by the flow rate delivered by the main pump 2a, the displacement of which has meanwhile been increased by means of its displacement compensating element to reach its calibration value (which is intermediate between the first value and the second value of the circuit 1).

[0057] It has in practice been ascertained that the described invention achieves the intended objects, and in particular, the fact is emphasized that the combined action of the first valve means and of the second valve means makes it possible to optimize the start of the auxiliary pumping means depending on the pressure difference at the ends of the user point located along the delivery line.

[0058] In addition, the use of two mutually separate, mechanically connected and mutually movable distributor elements makes it possible to define two stable operating positions, i.e., one with the auxiliary pump connected to the discharge and one with the auxiliary pump connected to the delivery line. In this way, the flow rate along the delivery line corresponds exactly to that required by the load, without energy dissipation due to partial lamination of the flow rate delivered by the auxiliary pump, which is exploited to its full potential, while the flow rate of the main pump is continuously adjusted.

[0059] The circuit covered by the present invention thus makes it possible to obtain a pressure difference at the ends of the user point which corresponds under all operating conditions to the design pressure, i.e., to the calibration of the pressure compensating element which serves as displacement regulator of the main pump.

Claims

1. Circuit for the flow rate control in a hydraulic circuit, comprising:

- main pumping means (2) comprising at least one main pump (2a) with variable displacement;
- a delivery line (3) connected to said main pump in a fluid-operated manner and connectable to a hydraulic circuit, where at least one user point (4) is arranged along said delivery line (3);
- auxiliary pumping means (5) comprising at least one auxiliary pump (5a);
- an auxiliary supply line (6) connected in a fluid-operated manner to said auxiliary pump (5a) and to said delivery line (3);
- at least one discharge tank (7, 8);
- valve means (9, 13) operable to set in communication/isolate said auxiliary pumping means (5) with/from said tank (7, 8);

characterized by the fact that said valve means (9, 13) comprise

first valve means (9) movable between at least a discharge position, wherein they set said auxiliary pumping means (5) in communication with said tank (7, 8), and a supply position, wherein they isolate said auxiliary pumping means (5) from said tank (7, 8),

at least one first driving line (10) of said first valve means (9), and comprise

second valve means (13) operable between at least a first working position, wherein they set said first driving line (10) in communication with one of either said tank (7, 8) or a source of the working fluid under pressure so as to bring said first valve means (9) to the supply position, and a second working position wherein they set said first driving line (10) in communication with the other of either said tank (7, 8) or the source of the working fluid under pressure so as to bring said first valve means (9) to the discharge position, at least a second driving line (14) and a third driving line (15) being provided operating from opposite sides on said second valve means (13), wherein said second driving line (14) communicates with said delivery line (3) upstream of said user point (4) and said third driving line (15) communicates with said delivery line (3) downstream of said user point (4), said second valve means (13) displacing to the first working position as a result of the attainment of a first predefined pressure difference between said second driving line (14) and said third driving line (15) and displacing to the second working position as a result of the attainment of a second predefined pressure difference between said second driving line (14) and said third driving line (15).

2. Circuit (1) according to claim 1, **characterized by** the fact that said second valve means (13) in the first working position set said first driving line (10) in communication with said source of the working fluid under pressure and, in the second working position, set said first driving line (10) in communication with said tank (7, 8).

3. Circuit (1) according to claim 1, **characterized by** the fact that said second valve means (13) in the first working position set said first driving line (10) in communication with said tank (7, 8) and, in the second working position, set said first driving line (10) in communication with said source of the working fluid under pressure.

4. Circuit (1) according to one or more of the preceding claims, **characterized by** the fact that said second valve means (13) comprise at least one hollow body (16) defining a housing seat (17) provided with at least one first port (18) communicating with said first driving line (10), with at least one second port (19) communicating with said source of the working fluid under pressure, with at least one third port (20) communicating with said third driving line (15) and with at least one fourth port (21) communicating with said tank (7, 8), and comprise at least a first distributor element (22) and a second distributor element (23) housed within said housing seat (17) in a sliding manner and mechanically connected to each other.

5. Circuit (1) according to claim 4, **characterized by** the fact that between said distributor elements (22, 23) is defined a first chamber (24), that between said first distributor element (22) and said body (16) is defined a second chamber (25) communicating with said second driving line (14), upstream of said user point (4) and that between said second distributor element (23) and said body (16) is defined a third chamber (26) communicating with said third port (20), said distributor elements (22, 23) being adapted, as a result of their displacement within said housing seat (17) to set in communication/isolate said first chamber (24) and said first port (18) with/from said second chamber (25) and said fourth port (21).

6. Circuit (1) according to claim 5, **characterized by** the fact that said second chamber (25) is set in communication with said second port (19).

7. Circuit (1) according to claim 5 or 6, **characterized by** the fact that said second valve means (13) comprise first elastic means (27) housed within said third chamber (26) and operating on said second distributor element (23).

8. Circuit (1) according to one or more of claims 5 to 7, **characterized by** the fact that said second valve means (13) comprise second elastic means (28) housed within said first chamber (24).

9. Circuit (1) according to claim 8, **characterized by** the fact that said second elastic means (28) are adapted to expand when said first chamber (24) is set in communication with said second port (19) and are adapted to compress when, as a result of the displacement of said distributor elements (22, 23), said first chamber (24) is set in communication with said fourth port (21).

10. Circuit (1) according to claim 9, **characterized by** the fact that said first distributor element (22) has a first abutment surface (29a) adapted to interact with a first stopping surface (29b) defined by said second distributor element (23) as a result of the pressurization of said first chamber (24) as a result of its connection to said second port (19), and has a second abutment surface (30a) adapted to interact with a second stopping surface (30b) defined by said second distributor element (23) as a result of the depressurization of said first chamber (24) as a result of its connection to said discharge tank (7, 8).

11. Circuit (1) according to claim 10, **characterized by** the fact that said first distributor element (22) and said second distributor element (23) move synchronously with each other during the displacements between the first working position and the second working position and by the fact that said first distributor element (22) moves with respect to said second distributor element (23) when said first chamber (24) is set in communication with said tank (7, 8) through said fourth port (21) and isolated from said second port (19) and when said first chamber (24) is set in communication with said second port (19) and isolated from said tank (7, 8).

12. Circuit (1) according to claim 2 and one or more of

claims 5 to 11, **characterized by** the fact that said first chamber (24) is communicating with said first port (18) regardless of the position of said second valve means (13).

13. Circuit (1) according to claim 12, **characterized by** the fact that said second port (19) is set in communication with said first port (18) in the first working position and by the fact that said first port (18) is set in communication with said fourth port (21) in the second working position.

14. Circuit (1) according to claim 3 and one or more of claims 4 to 11, **characterized by** the fact that said first chamber (24) is separate from said first port (18).

15. Circuit (1) according to claim 14, **characterized by** the fact that said first chamber (24) is set in communication with said fourth port (21) in the second working position, and by the fact that said first chamber (24) is set in communication with said second port (19) in the first working position.

16. Circuit (1) according to claims 14 and 15, **characterized by** the fact that said second port (19) is set in communication with said first port (18) in the second working position and by the fact that said first port (18) is set in communication with said fourth port (21) in the first working position.

17. Circuit (1) according to claim 11 and one or more of claims 12 to 16, **characterized by** the fact that said first distributor element (22) and said second distributor element (23) move synchronously with each other from the first working position towards the second working position counteracting said first elastic means (27), with said first abutment surface (29a) resting on said first stopping surface (29b), by the fact that said first distributor element (22) moves with respect to said second distributor element (23) when said first chamber (24) is set in communication with said fourth port (21) and isolated from said second port (19), by the fact that said first distributor element (22) and said second distributor element (23) move synchronously with each other from the second working position towards the first working position, with said second abutment surface (30a) resting on said second stopping surface (30b), and by the fact that said first distributor element (22) moves with respect to said second distributor element (23) when said first chamber (24) is set in communication with said second port (19) and isolated from said fourth port (21).

18. Circuit (1) according to claims 16 and 17, **characterized by** the fact that as a result of the displacement of said first distributor element (22) with respect to said second distributor element (23) when said first chamber (24) is set in communication with said fourth port (21) and isolated from said second port (19), said first port (18) is isolated from said fourth port (21) and communicating with said second port (19), and by the fact that as a result of the displacement of said first distributor element (22) with respect to said second distributor element (23) when said first chamber (24) is set in communication with said second port (19) the connection between said first port (18) and said fourth port (21) opens.

19. Circuit (1) according to one or more of the preceding claims, **characterized by** the fact that said auxiliary pump (5a) is of the fixed displacement type and by the fact that said first valve means (9) are adapted to set said auxiliary supply line (6) in communication with said tank (7, 8) in the discharge position and to isolate said auxiliary supply line (6) from said tank (7, 8) in the supply position.

20. Circuit (1) according to one or more of claims 1 to 19, **characterized by** the fact that said auxiliary pump (5a) is of the variable displacement type, by the fact that said auxiliary pumping means (5) comprise at least one auxiliary control line (5b) adapted to adjust the displacement of said auxiliary pump (5a) and by the fact that said first valve means (9) are adapted to set said auxiliary control line (5b) in communication with said tank (7, 8) in the discharge position, so as to reduce the displacement of said auxiliary pump (5a), and to set said auxiliary control line (5b) in communication with said auxiliary supply line (6) in the supply position, so as to increase the displacement of said auxiliary pump (5a).

21. Circuit (1) according to one or more of the preceding claims, **characterized by** the fact that the active areas facing said first chamber (24) are equal to or greater than the useful section of the second driving line (14) and of the third driving line (15).

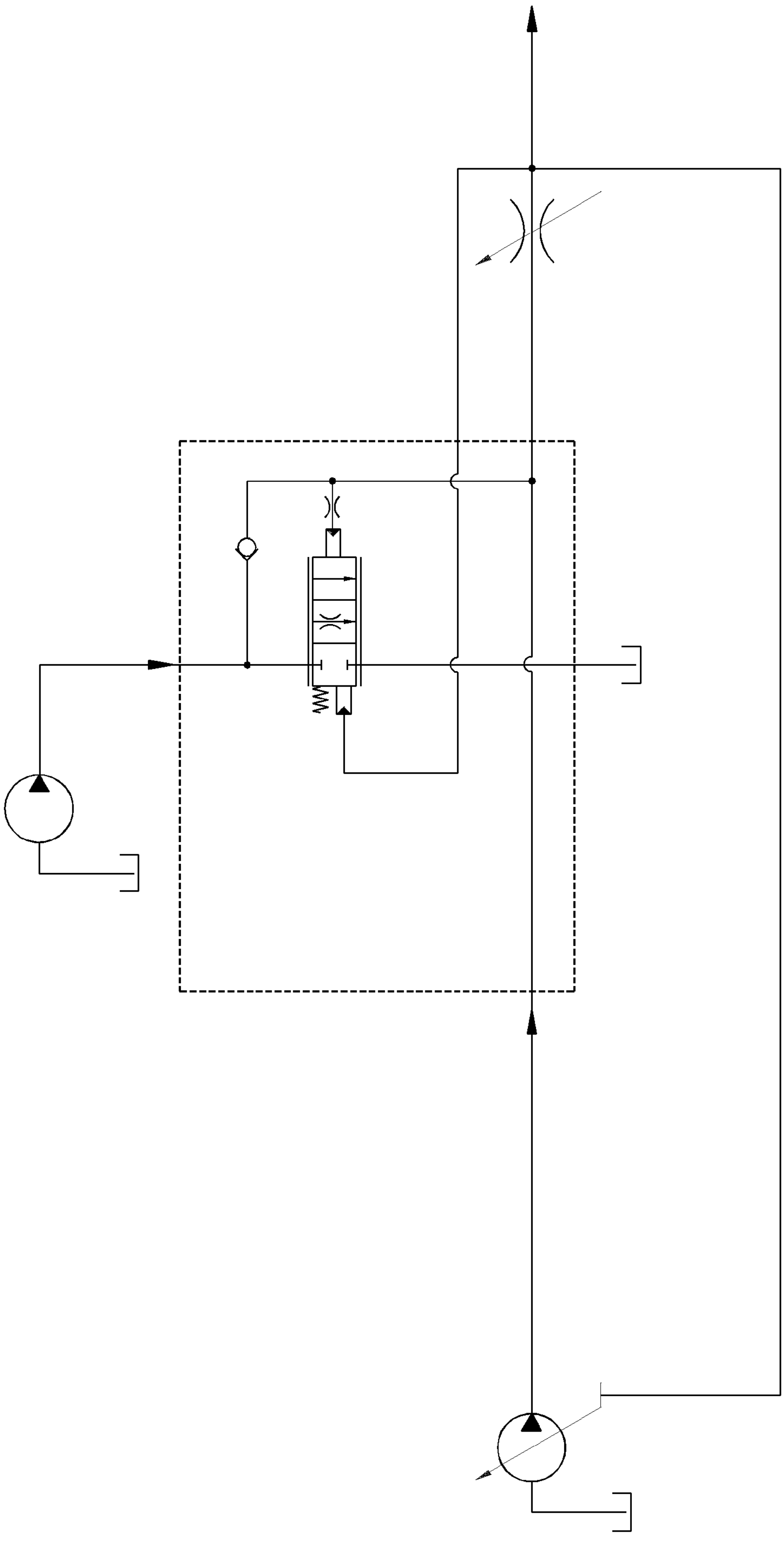


Fig.1A
PRIOR ART 1

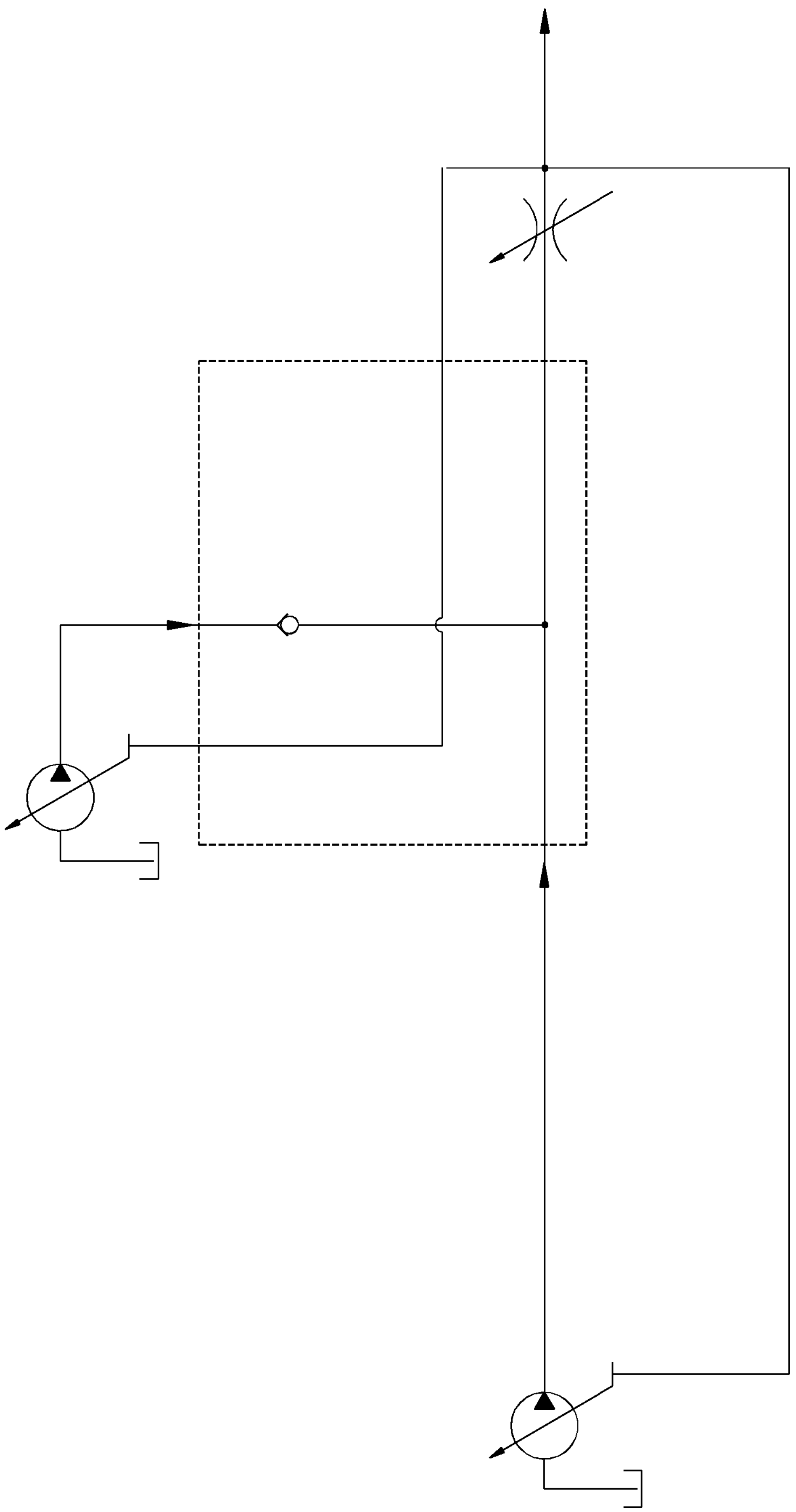


Fig.1B
PRIOR ART 2

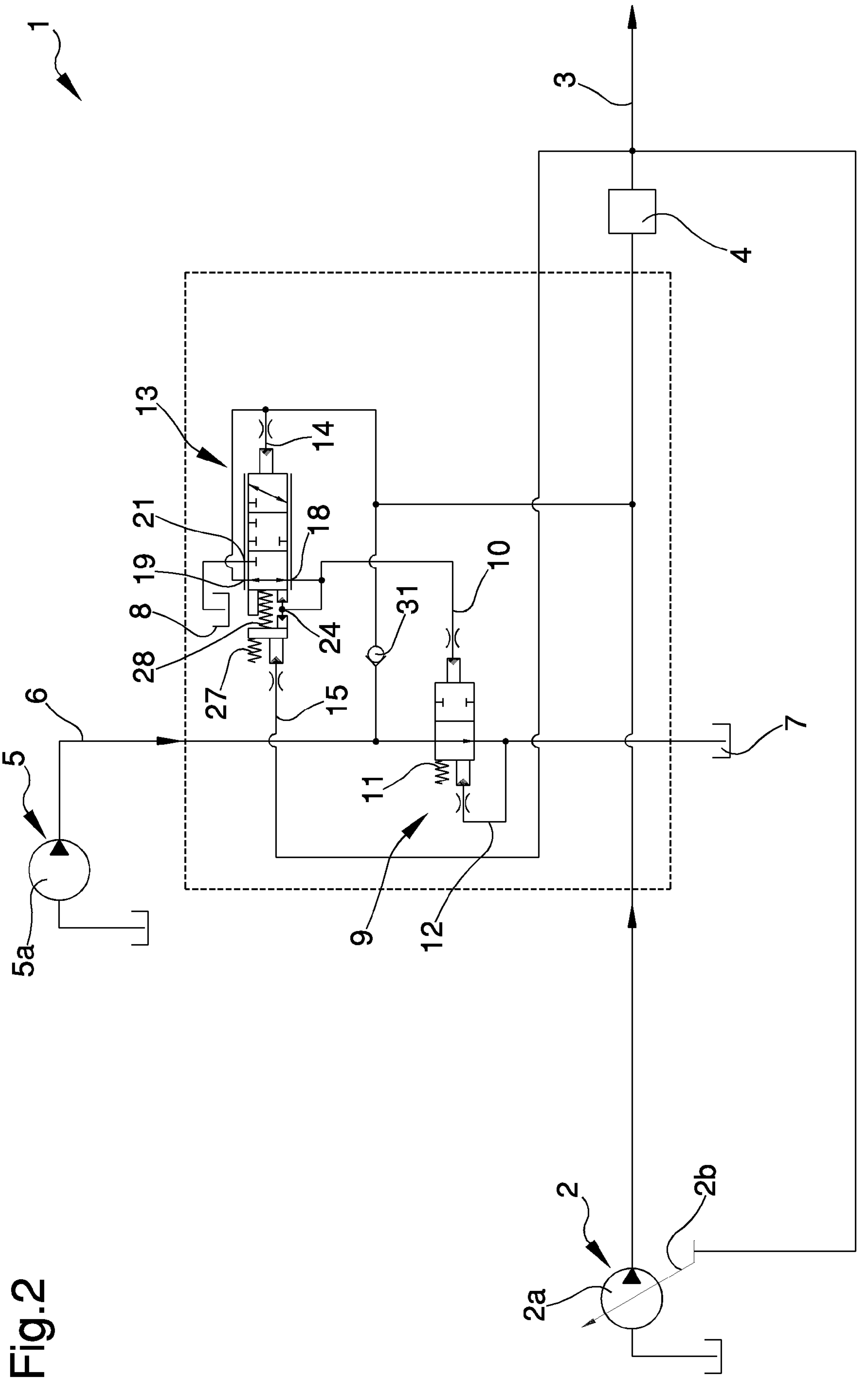


Fig.2

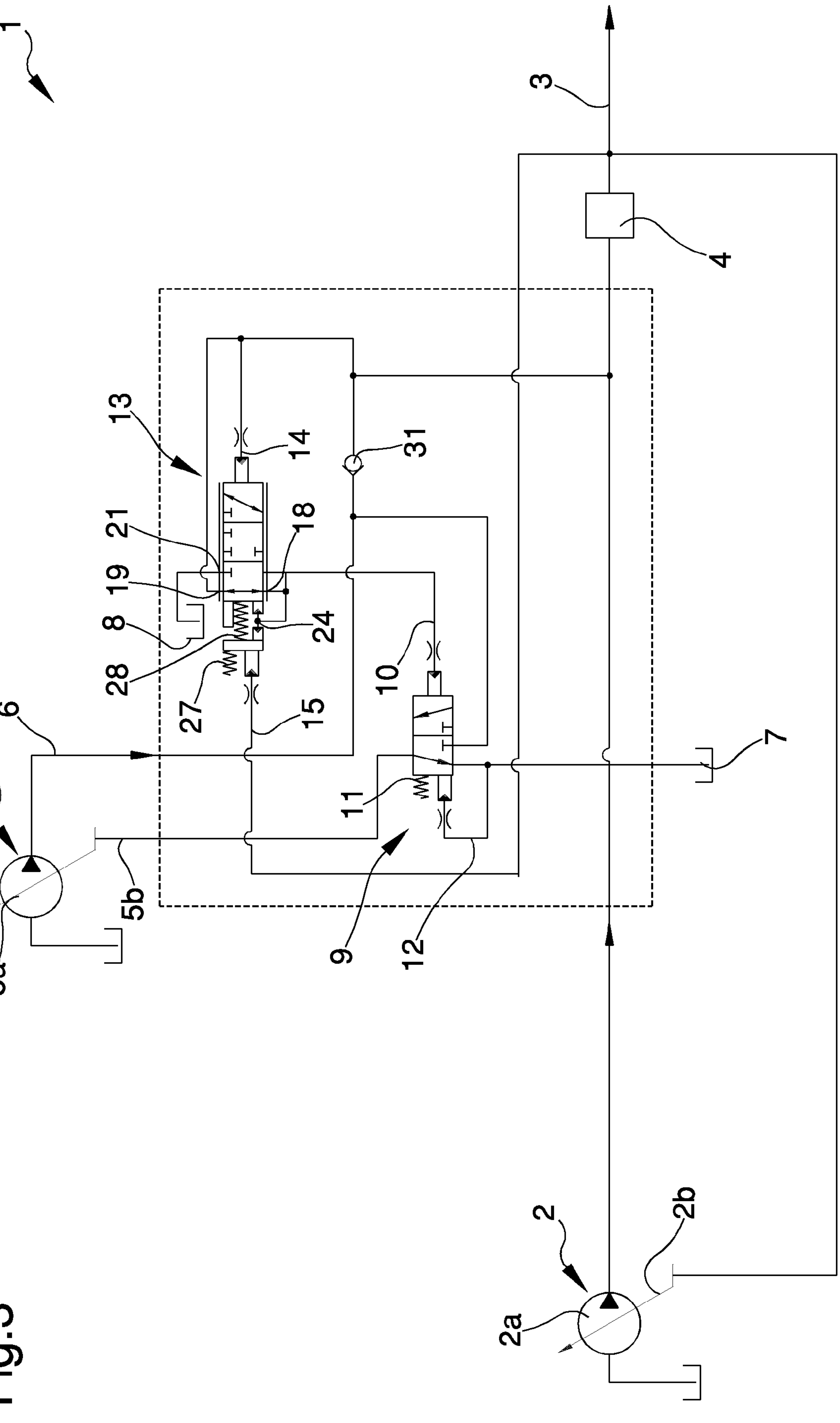


Fig.3

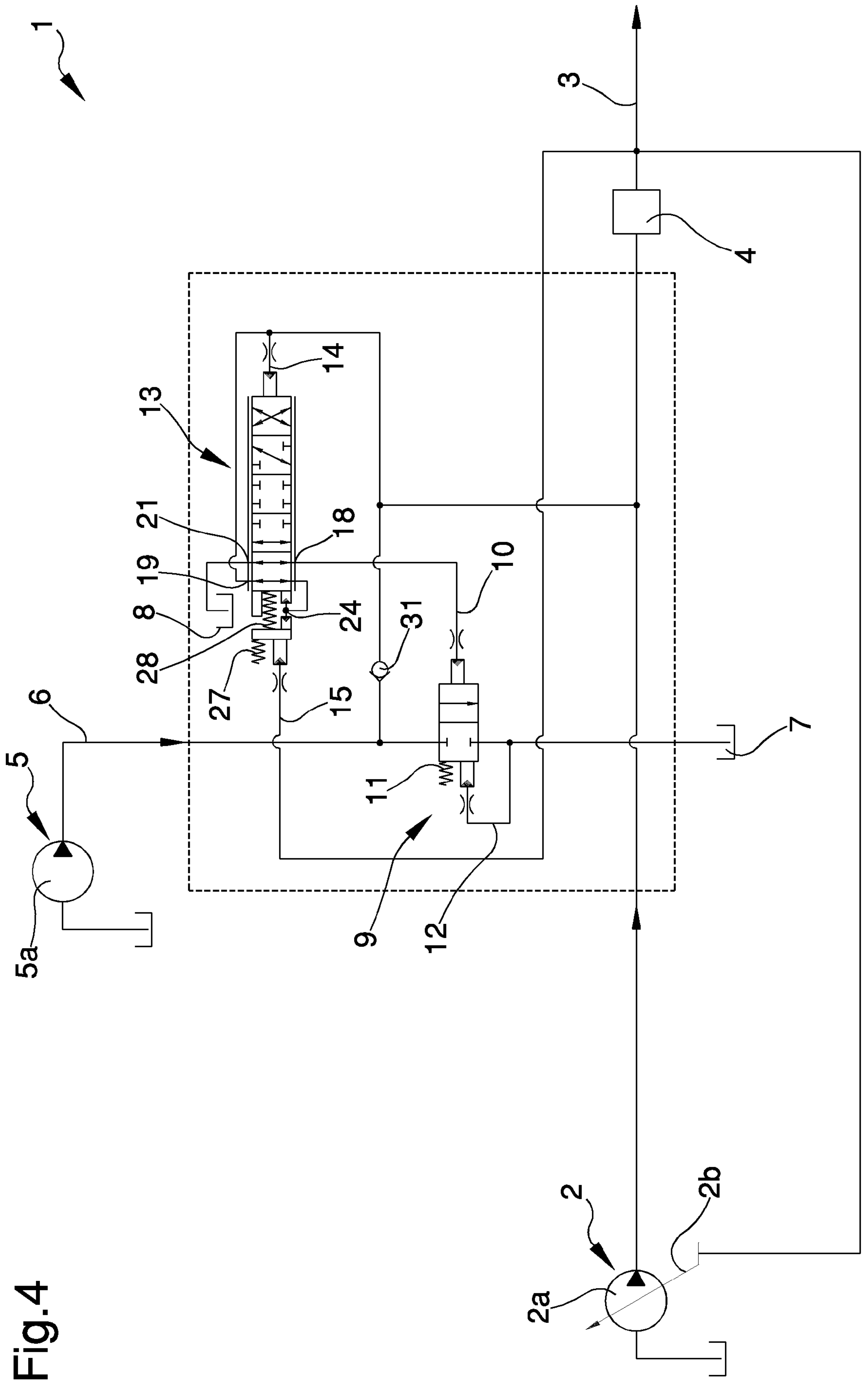


Fig.4

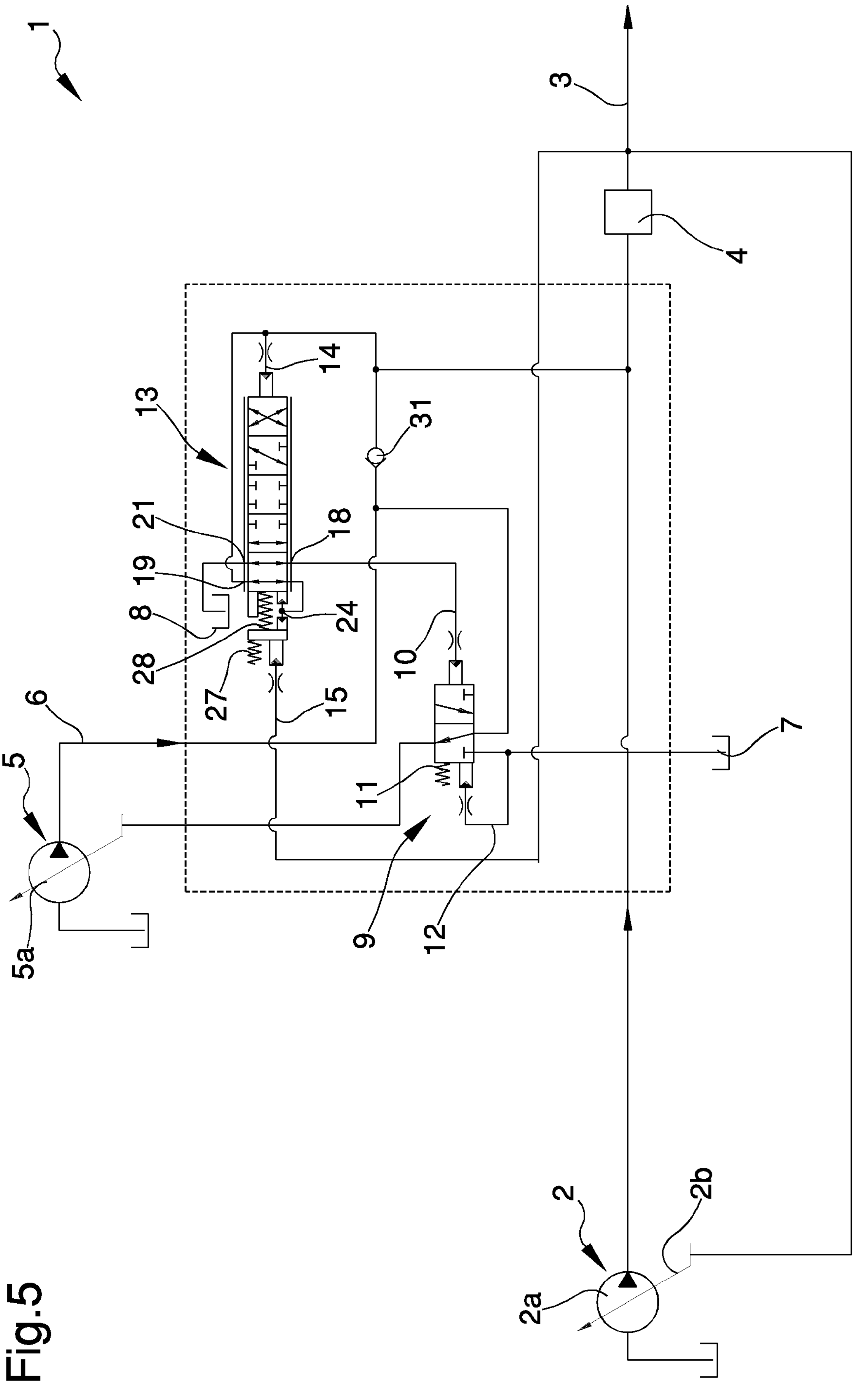


Fig.5

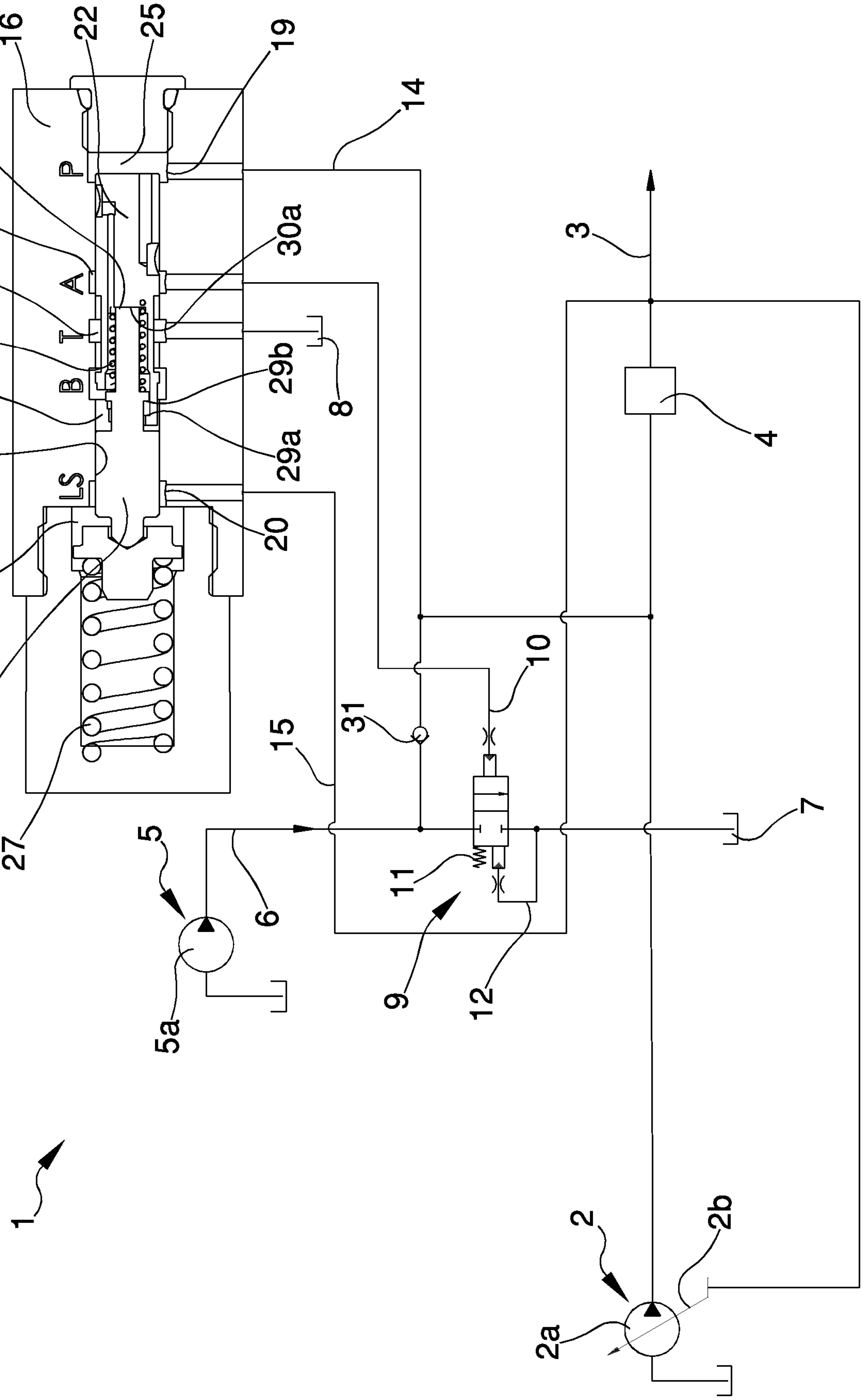

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Fig.6

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 7507

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F04B
F15B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 February 2025	Homan, Peter

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