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(71) Applicant: **Atlantic Fluid Tech S.r.l.**
41018 San Cesario sul Panaro (MO) (IT)

(72) Inventor: **STORCI, Christian**
41121 Modena (IT)

(74) Representative: **Villanova, Massimo et al**
Luppi Intellectual Property Srl
Viale Corassori, 54
41124 Modena (IT)

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(54) **ACTUATOR CONTROL DEVICE**

(57) A control device of a linear hydraulic actuator of an earth-moving machine is described, in which the device comprises a control valve provided with a first position in which it allows a supply flow of the operating fluid towards the hydraulic actuator and a second position in which it allows a discharge flow towards a distributor, an anti-vibration line which connects a pilot line of the control valve with a hydraulic line between the control valve and the distributor, and a pressure valve located in the anti-vibration line and configured to open at a certain pressure value when the movable member of the hydraulic actuator reaches the end of its stroke and if the operating fluid circuit is intact, in order to avoid an undesired generation of vibrations.

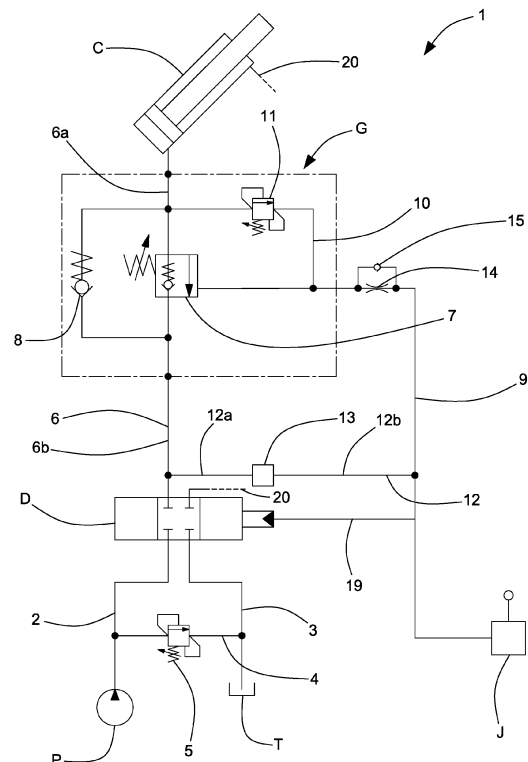


Fig. 4

Description

Background of the invention

[0001] The invention relates to a device for controlling a hydraulic actuator, in particular a linear hydraulic actuator.

[0002] Specifically, but not exclusively, the invention can be applied to control a hydraulic actuator of a earth-moving machine (for example an excavator) and/or a load-lifting machine.

[0003] The prior art comprises the patent publication EP 3228580 A1 which shows a device for controlling the descent of a load carried by a hydraulic cylinder of a load-lifting apparatus.

[0004] Patent publication GB 2514112 A shows a control valve with an inlet and outlet of the hydraulic fluid and a pilot duct connected to the inlet by means of a check valve which allows the flow only in the direction going from the pilot duct to the inlet.

[0005] Patent publication JP 4890147 B2 shows a device for controlling the descent of a load comprising a check valve arranged between a hydraulic actuator and a pipe at risk of breakage, a pilot pipe for piloting the check valve, a valve for controlling the pressure of the pilot pipe and a check valve arranged to prevent the transmission of pressure from the pipe at risk of breakage to the pressure control valve.

[0006] Patent publication JP 2014206245 A shows a device which reduces the speed of descent of the load and which comprises a control valve configured so as to reduce its degree of opening when the pressure in a supply line of a hydraulic actuator is reduced.

[0007] Patent publication EP 3312436 A1 shows an anti-breakage tube device with a safety valve arranged between the pilot line and the main hydraulic line, in which such safety valve is closed in case of intact tube and opens automatically in case of tube breakage.

[0008] Patent publication US 4936032 A shows a device according to the preamble of claim 1.

[0009] One of the problems of known devices for controlling a hydraulic actuator, in particular in earth-moving machines and/or load-lifting machines, is represented by the undesired generation of vibrations in the device when the movable part of the actuator reaches the end of its stroke, generally when the operating arm of the machine is in the maximum extension configuration.

Summary of the invention

[0010] One object of the invention is to provide a control device able to remedy the aforementioned drawback of the prior art.

[0011] One object of the invention is to provide a valve assembly which integrates some circuit elements usable in the control device.

[0012] An advantage is to effectively avoid the generation of vibrations in the device when the mobile part of

the actuator reaches the end of its stroke.

[0013] An advantage is to provide a control device which makes available a wide opening for the passage of the operating fluid in the phase of raising the load, in particular when the device controls a hydraulic actuator of a earth-moving machine and/or a load-lifting machine.

[0014] An advantage is to realize a device which is constructively simple and economical for controlling a hydraulic actuator.

[0015] These objects and advantages, and others, are achieved by a control device according to one or more of the claims below.

[0016] In one example, a control device comprises a hydraulic line that connects a distributor of an operating fluid to a hydraulic actuator, a control valve arranged on the hydraulic line and provided with a first position in which it allows a supply flow of the operating fluid to the hydraulic actuator and a second position in which it allows a discharge flow towards the distributor, a pilot line of the control valve, an anti-vibration line that connects the pilot line with the hydraulic line, and a pressure valve arranged in the anti-vibration line and configured to open at a given pressure value corresponding to a situation in which the movable member of the hydraulic actuator reaches the end of its stroke, so as to avoid an undesired generation of vibrations.

[0017] The pressure valve located in the anti-vibration line is configured to open only if the operating fluid circuit is intact, in particular it does not open in the event of non-integrity of the flexible hose at risk of breakage.

[0018] Essentially, the pressure valve is configured to open the anti-vibration line (which represents a sort of bypass line) when the pressure exceeds a certain value, without the risk of opening in the event of a tube rupture, solving the problem of generation of vibrations in the hydraulic system.

Brief description of the drawings

[0019] The invention can be better understood and implemented with reference to the attached drawings which illustrate non-limiting examples of its implementation, in which:

Figure 1 shows a partial hydraulic diagram of a first example of a control device according to the invention;

Figure 2 shows a partial hydraulic diagram of a second example of a control device according to the invention;

Figure 3 shows a hydraulic diagram of a third example of a control device according to the invention;

Figure 4 shows a hydraulic diagram of a fourth example of a control device made according to the invention;

Figure 5 shows a hydraulic diagram of a fifth example of a control device according to the invention;

Figure 6 shows a hydraulic diagram of a sixth exam-

ple of a control device according to the invention;
Figures 7 to 13 show hydraulic diagrams of some
embodiments of anti-vibration valve means usable
in the devices of Figures 1 to 6.

Detailed description

[0020] In the above figures, for greater clarity, similar elements of different embodiments have been indicated with the same numbering.

[0021] With reference to the aforementioned figures, a control device for a hydraulic actuator C has been indicated as a whole. The control device 1 may be used, in particular, to control a linear hydraulic actuator C (for example a double-acting actuator, as in the illustrated examples). The hydraulic actuator C may be, in particular, an actuator of a earth-moving machine (for example an excavator) and/or a load-lifting machine.

[0022] The hydraulic actuator C may be configured, in particular, to carry out a load descent by gravity.

[0023] The control device 1 may comprise, in particular, at least one pump P for supplying an operating fluid. The supply pump P may comprise, in particular, a hydraulic pump (for example of a known type) suitable for feeding a hydraulic actuator of a earth-moving machine (excavator) and/or a load-lifting machine.

[0024] The control device 1 may comprise, in particular, at least one delivery line 2 connected to the (delivery of) the pump P.

[0025] The control device 1 may comprise, in particular, at least one distributor D of the operating fluid. The distributor D may, in particular, be connected to the delivery line 2. The distributor D may comprise, in particular, a distributor (for example of a known type) suitable for distributing the operating fluid in a hydraulic circuit that supplies power to a hydraulic actuator of an earth-moving machine (excavator) and/or a load-lifting machine. The distributor D may comprise, in particular, a four-way and three-position distributor, although it is possible to provide for the use of other types of distributor.

[0026] The control device 1 may comprise, in particular, at least one discharge line 3 connected to the distributor D. The discharge line 3 may be destined, as in these examples, to the connection with a discharge T of the operating fluid.

[0027] The control device 1 may comprise, in particular, at least one bypass line 4 arranged between the delivery line 2 and the discharge line 3. The control device 1 may comprise, in particular, pressure control means 5 operating in the bypass line 4 and configured to open at a first pressure value P1 (for example P1 between 300 and 350 bar). The pressure control means 5 may comprise, for example, at least one pressure relief valve.

[0028] The control device 1 may comprise, in particular, at least one hydraulic line 6 (main line) connected to the distributor D and intended for connection to the hydraulic actuator C.

[0029] The control device 1 may comprise, in particu-

lar, control valve means 7 arranged in the hydraulic line 6. The control valve means 7 may comprise, in particular, a first position in which it allows a supply flow towards the hydraulic actuator C and at least a second position in which it allows a discharge flow towards the distributor D. The control valve means 7 may comprise at least a second position in which it prevents the flow of supply towards the hydraulic actuator C. The control valve means 7 may comprise, in particular, at least one valve for controlling the descent of the load.

[0030] The hydraulic line 6 may comprise, in particular, a first portion 6a comprised between the control valve means 7 and the hydraulic actuator C. The hydraulic line 6 may comprise, in particular, a second portion 6b included between the distributor D and the control valve means 7. At least a part of the second portion 6b of the hydraulic line 6 may comprise, in particular, a flexible tube (at risk of breakage).

[0031] The control device 1 may comprise, in particular as in the examples of Figures 1, 3, 4, 5 and 6, at least one check valve 8 arranged in parallel with respect to the control valve means 7 to allow a supply flow to the hydraulic actuator C and prevent a return flow to the distributor D.

[0032] The control device 1 may comprise, in particular, at least one pilot line 9 arranged to pilot the control valve means 7 and intended for connection with command means J configured to allow the control of the control device 1. The command means J may comprise, in particular, at least one member (lever) operable by an operator and at least one peripheral device which transforms the movements of the aforesaid operating member into a series of electrical or electronic signals which enable the control device 1 to be controlled. The command means J may be connected to a central control unit (for example a programmable electronic processor) which governs the operating machine on which the control device 1 is installed. The command means J may comprise, in particular, a joystick (for example of a known type) usable in an earth-moving machine (excavator) and/or in a load-lifting machine.

[0033] The control device 1 may comprise, in particular, at least one safety line 10 which connects the pilot line 9 with the first portion 6a of the hydraulic line 6 comprised between the control valve means 7 and the hydraulic actuator C.

[0034] The control device 1 may comprise, in particular, safety valve means 11 arranged in the safety line 10 and configured to open at a second pressure value P2 higher than the first pressure value P1. The second pressure value P2 may be, for example, between 360 and 420 bar. The safety valve means 11 may comprise, for example, a pressure relief valve.

[0035] The control device 1 may comprise, in particular, at least one anti-vibration line 12 which connects the pilot line 9 with the hydraulic line 6, in particular with the second portion 6b of the hydraulic line 6 included between the control valve means 7 and the distributor D.

[0036] The control device 1 may comprise, in particular, anti-vibration valve means 13 arranged in the anti-vibration line 12 and configured to open at a third pressure value P3 lower than the first pressure value P1. The third pressure value P3 may be, for example, between 240 and 300 bar.

[0037] The third pressure value P3 may be, in particular, lower than the first pressure value P1 of a difference ΔP ($P3 = P1 - \Delta P$) between 10 and 70 bar, or between 20 and 60 bar, or between 30 and 50 bar.

[0038] The anti-vibration line 12 may comprise, in particular, a first line portion 12a arranged between the hydraulic line 6 and the anti-vibration valve means 13 and a second line portion 12b arranged between the anti-vibration valve means 13 and the pilot line 9.

[0039] The anti-vibration valve means 13 may comprise, in particular, at least one circuit element which comprises at least one pressure valve (Figures 7 to 13) and/or at least one check valve (Figure 7) and/or at least one pressure relief valve (Figures 10 and 13) and/or at least one compensated pressure relief valve (Figure 9) and/or at least one proportional two-way and two-position valve (Figure 8) and/or at least one two-way and two-position proportional valve urged to close by elastic means (Figure 8) and/or at least one two-way and two-position proportional valve associated in parallel with a pressure-limiting valve M (Figure 11) and/or at least one pressure valve integrated in a selector valve (Figure 12).

[0040] With reference to the examples of Figures 1, 2 and 6, it can be seen that in these cases the anti-vibration valve means 13 comprises at least one pressure-limiting valve (such as that of Figure 13). It is possible to foresee that, in the examples of Figures 1, 2 and 6, in addition to, or in replacement of the pressure relief valve (such as that of Figure 13) arranged in the anti-vibration line 12, at least one of the circuit elements shown in Figures 7 to 12 is used.

[0041] With reference to the examples of Figures 3 and 4, it can be seen that the anti-vibration valve means 13 has been represented with a generic element (in the form of a box) which may be replaced, for example, by one or more of the elements of circuit represented in Figures 7 to 13.

[0042] The anti-vibration valve means 13 may comprise, in particular, as in the example of Figure 5, at least one three-way valve (similar to the valve of Figure 12) provided with at least one closing position in which the three-way valve closes a communication between the pilot line 9 and the first portion 12a of the anti-vibration line 12, leaving open a communication between the pilot line 9, the safety line 10 and the second portion 12b of the anti-vibration line 12. The three-way valve may be provided with at least one opening position in which the three-way valve opens the communication between the pilot line 9 and the first portion 12a of the anti-vibration line 12, leaving open the communication between the pilot line 9 and the safety line 10 and the second portion 12b of the anti-vibration line 12.

[0043] The aforementioned three-way valve may comprise, in particular, a valve configured to be normally in the closed position. In particular, the three-way valve may comprise, as in these examples, elastic means arranged to urge the three-way valve in the closed position.

[0044] The aforementioned three-way valve essentially comprises a pressure valve (in particular, a pressure-limiting valve) and a selector valve (which may be substantially similar to the selector valve 16 which will be described below) integrated with each other in a single circuit element.

[0045] The control device 1 may comprise, in particular, throttling means 14 arranged in the pilot line 9 between the safety valve means 11 and the command means J of the control device 1. The throttling means 14 may comprise, for example, an orifice, in particular an orifice with adjustable opening (for example with a grain).

[0046] The control device 1 may comprise, in particular, unidirectional flow means 15 arranged in parallel with respect to the throttling means 14 to prevent a flow towards the command means J of the control device 1.

[0047] The throttling means 14 may be arranged, as in the examples of Figures 1, 2, 3, 5 and 6, between the anti-vibration valve means 13 and the command means J of the control device 1.

[0048] The control device 1 may comprise, in particular, at least one selector valve 16 (Figures 2 and 6) which may comprise at least one first position in which the selector valve 16 opens a communication between the pilot line 9 and the anti-vibration valve means 13 and closes a communication between the pilot line 9 and the safety valve means 11. The selector valve 16 may comprise at least one second position in which the selector valve 16 closes the communication between the pilot line 9 and the anti-vibration valve means 13 and opens the communication between the pilot line 9 and the safety valve means 11.

[0049] The control device 1 may comprise, in particular, at least one drainage line 17 (Figure 6) connected to the anti-vibration line 12. The drainage line 17 may be connected to a portion of the anti-vibration line 12 included between the anti-vibration valve means 13 and the pilot line 9. The drainage line 17 is intended for connection to a drain T.

[0050] The control device 1 may comprise, in particular, at least one speed reduction valve 18 arranged to control the flow in the drainage line 17. In particular, the speed reduction valve 18 may be urged to open by elastic means. In particular, the speed reduction valve 18 may be driven in closing by a pilot pressure present on the side of the anti-vibration valve means 13 arranged towards the control valve means 7. The speed reduction valve 18 may comprise, for example, a proportional type valve. The speed reduction valve 18 may comprise, in particular, a two-way and two-position valve.

[0051] The control device 1 may comprise, in particular, at least one control line 19 arranged to control the distributor D and intended for connection to the command

means J of the control device 1.

[0052] 20 indicates a hydraulic line (only partially represented) which connects the distributor D with the hydraulic actuator C. The hydraulic lines 6 and 20 are, in particular, the lines connected to two separate chambers of the double-acting actuator. In particular, the hydraulic line 6 may be connected to a first chamber of the hydraulic actuator C (for example a larger chamber or piston-side chamber) and the hydraulic line 20 may be connected to a second chamber of the hydraulic actuator C (for example a minor chamber or rod-side chamber). The two chambers of the hydraulic actuator C may be opposite each other and/or separated by a piston. The hydraulic line 20 may comprise, in particular, balancing means (for example of a known type, not shown), such as for example an overcenter valve.

[0053] The control device 1 may comprise, in particular as in the examples of Figures 3, 5 and 6, at least one valve unit G (schematized in the figures with a rectangle with dash and dot line) which integrates the following hydraulic circuit elements in a single block: at least a portion of the hydraulic line 6, the control valve means 7, at least a portion of the pilot line 9, the safety line 10, the safety valve means 11, the anti-vibration line 12 and the anti-vibration valve means 13. In the example of Figure 6 the valve unit G also integrates the speed reduction valve 18.

[0054] In the example of Figure 4, the anti-vibration valve means 13 is arranged separated and not integrated with respect to the control valve means 7.

[0055] The control device 1 may comprise, in particular, anti-vibration means (for example the anti-vibration line 12 and the anti-vibration valve means 13) configured so as to open only when the movable member (piston) of the hydraulic actuator C is at the end of the stroke and when the circuit is intact, in particular when the flexible hose at risk of breakage is intact. The aforementioned anti-vibration means may be connected, as in these examples, to the hydraulic line 6.

[0056] It has been found, in fact, that the use of the aforesaid anti-vibration means, for example like those described above, by opening when the movable member of the hydraulic actuator C reaches the end of its stroke, considerably reduces or completely avoids the vibration generation in the control device and other parts of the hydraulic circuit that supplies the hydraulic actuator.

Claims

1. Control device (1) of an hydraulic actuator (C), comprising:

- a pump (P) for feeding an operating fluid;
- a delivery line (2) connected to said pump (P);
- a distributor (D) of the operating fluid connected to said delivery line (2);
- a discharge line (3) connected to said distrib-

utor (D) and intended for connection to a discharge (T) of the operating fluid;

- a bypass line (4) arranged between said delivery line (2) and said discharge line (3);
- pressure control means (5) arranged in said bypass line (4) and configured to open at a first pressure value (P1);
- a hydraulic line (6) connected to said distributor (D) and intended for connection to an hydraulic actuator (C);
- control valve means (7) arranged in said hydraulic line (6) and comprising at least one first position in which it allows a supply flow towards the hydraulic actuator (C) and at least one second position in which it allows a discharge flow towards said distributor (D);
- a pilot line (9) arranged to pilot said control valve means (7) and intended for connection to command means (J);
- a safety line (10) connecting said pilot line (9) with a first portion (6a) of said hydraulic line (6) between said control valve means (7) and the hydraulic actuator (C);
- safety valve means (11) arranged in said safety line (10);

characterized in that:

- said safety valve means (11) is configured to open to a second pressure value (P2) higher than said first pressure value (P1);
- said control device (1) comprises an anti-vibration line (12) connecting said pilot line (9) with a second portion (6b) of said hydraulic line (6) between said control valve means (7) and said distributor (D);
- said control device (1) comprises anti-vibration valve means (13) arranged in said anti-vibration line (12) and configured to open to a third pressure value (P3) lower than said first pressure value (P1).

2. Device according to claim 1, wherein said anti-vibration valve means (13) comprises at least one circuit element selected in a group which includes: a pressure valve, a check valve, a pressure relief valve, a compensated pressure relief valve, a two-way proportional valve, a two-way proportional valve stressed in closure by elastic means, a two-way proportional valve associated in parallel with a pressure relief valve.

3. Device according to claim 1 or 2, wherein said anti-vibration valve means (13) comprises a three-way valve with at least one closing position in which it closes a communication between said pilot line (9) and said second portion (6b) of said hydraulic line (6) through said anti-vibration line (12) leaving open

a communication between said pilot line (9) and said safety line (10), and at least one opening position in which it opens the communication between said pilot line (9) and said second portion (6b) of said hydraulic line (6) through said anti-vibration line (12) leaving open the communication between said pilot line (9) and said safety line (10), said three-way valve being normally in closed position by the action of elastic means.

4. Device according to any one of the preceding claims, comprising a valve unit (G) which integrates in a single block: at least a portion of said hydraulic line (6), said control valve means (7), at least a portion of said pilot line (9), said safety line (10), said safety valve means (11), said anti-vibration line (12) and said anti-vibration valve means (13).
5. Device according to any one of the preceding claims, comprising throttling means (14) arranged in said pilot line (9) between said safety valve means (11) and the command means (J) of the control device (1), unidirectional flow means being arranged in parallel with said throttling means (14) to prevent flow towards the command means (J).
6. Device according to claim 5, wherein said throttling means (14) is arranged between said anti-vibration valve means (13) and the command means (J) of the control device (1).
7. Device according to any one of the preceding claims, comprising a selector valve with three ways and with at least one first position in which said selector valve opens a communication between said pilot line (9) and said anti-vibration valve means (13) and closes a communication between said pilot line (9) and said safety valve means (11), and at least one second position in which said selector valve closes the communication between said pilot line (9) and said anti-vibration valve means (13) and opens the communication between said pilot line (9) and said safety valve means (11).
8. Device according to any one of the preceding claims, comprising a drain line (17) connected to a portion (12b) of said anti-vibration line (12) comprised between said anti-vibration valve means (13) and said pilot line (9) and intended for connection to a drain (T), a speed reduction valve (18) being arranged to control said drain line (17).
9. Device according to claim 8, wherein said speed reduction valve (18) is stressed in opening by elastic means and is piloted in closing by a pilot pressure present on one side of said anti-vibration valve means (13) arranged towards said hydraulic line (6).

10. Device according to claim 8 or 9, wherein said speed reduction valve (18) comprises a two-way valve.

11. Device according to any one of the preceding claims, comprising a control line (19) arranged to control said distributor (D) and intended for connection to the command means (J) of the control device (1).

12. Valve assembly integrating in a single block the following hydraulic circuit elements according to any one of the preceding claims: at least a portion of a hydraulic line (6), control valve means (7), at least a portion of a pilot line (9), a safety line (10), safety valve means (11), an anti-vibration line (12) and anti-vibration valve means (13).

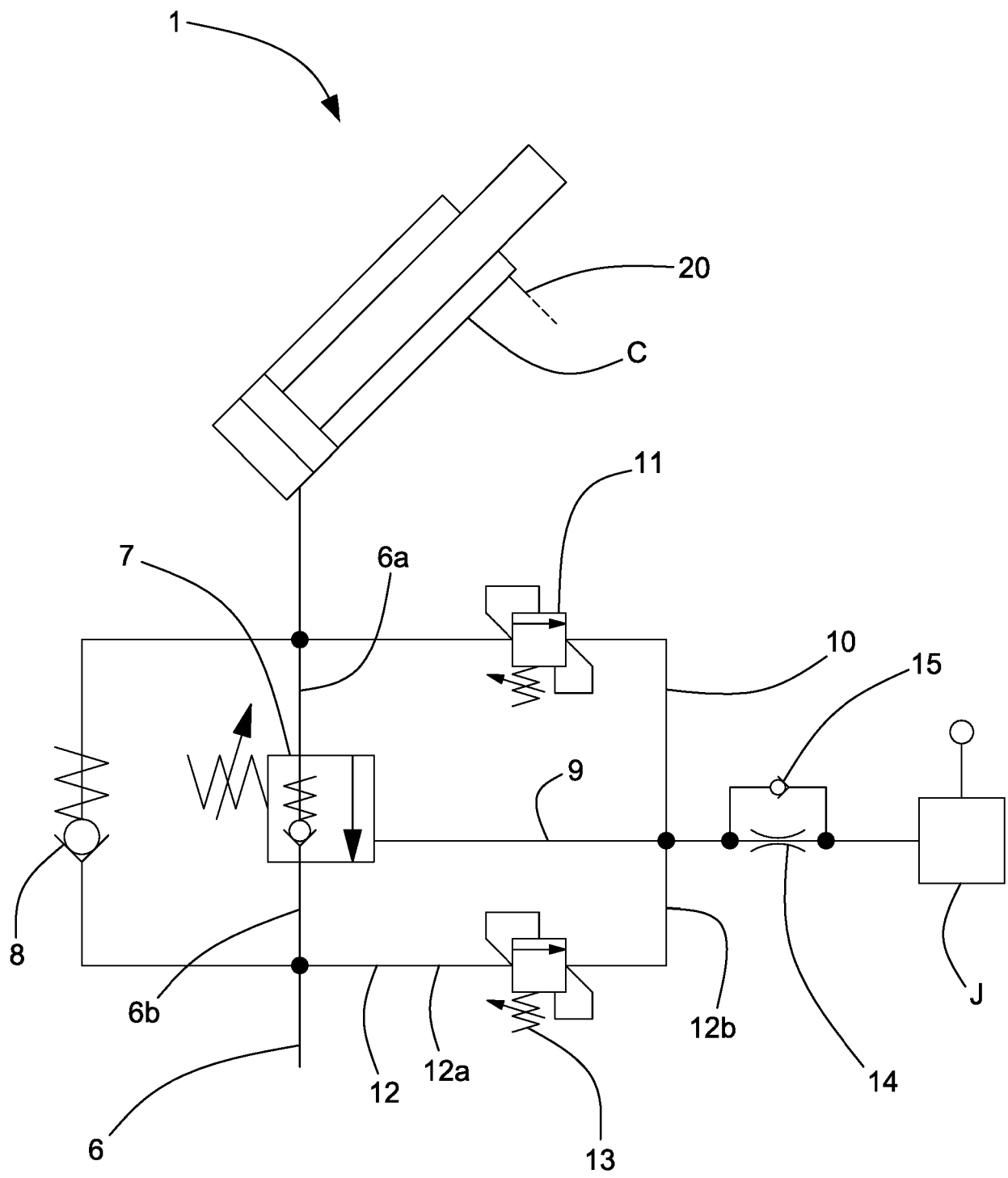


Fig. 1

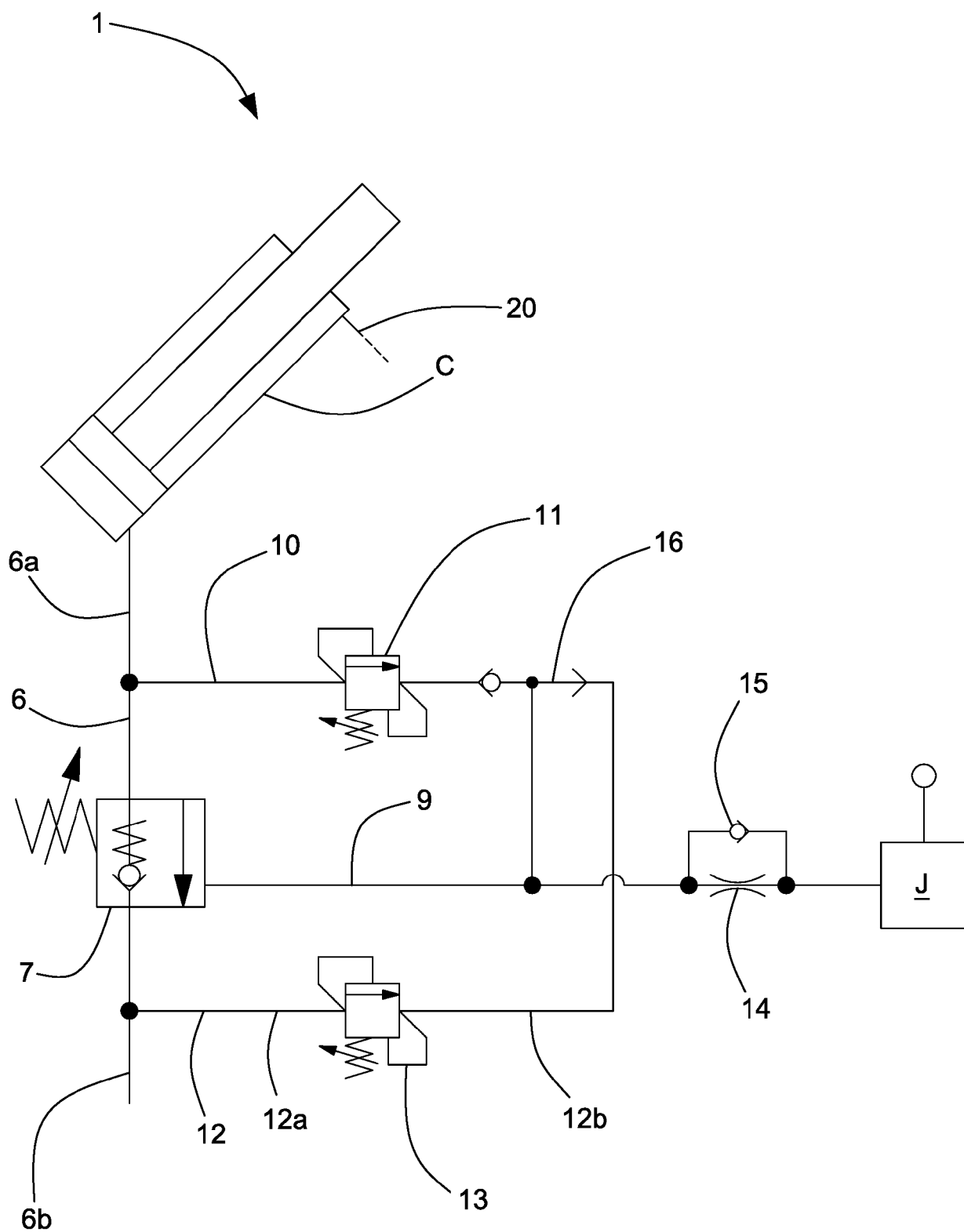


Fig. 2

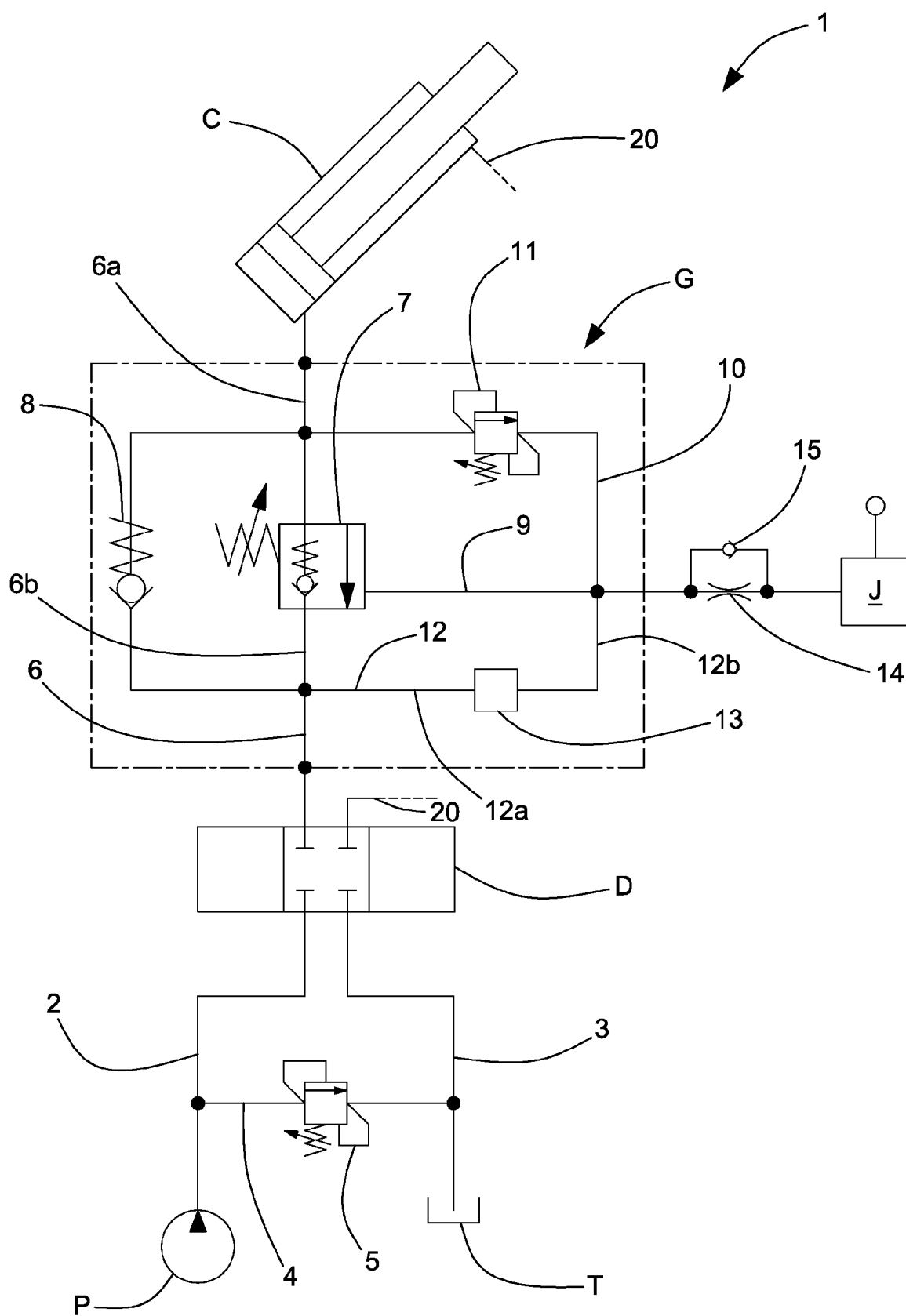


Fig. 3

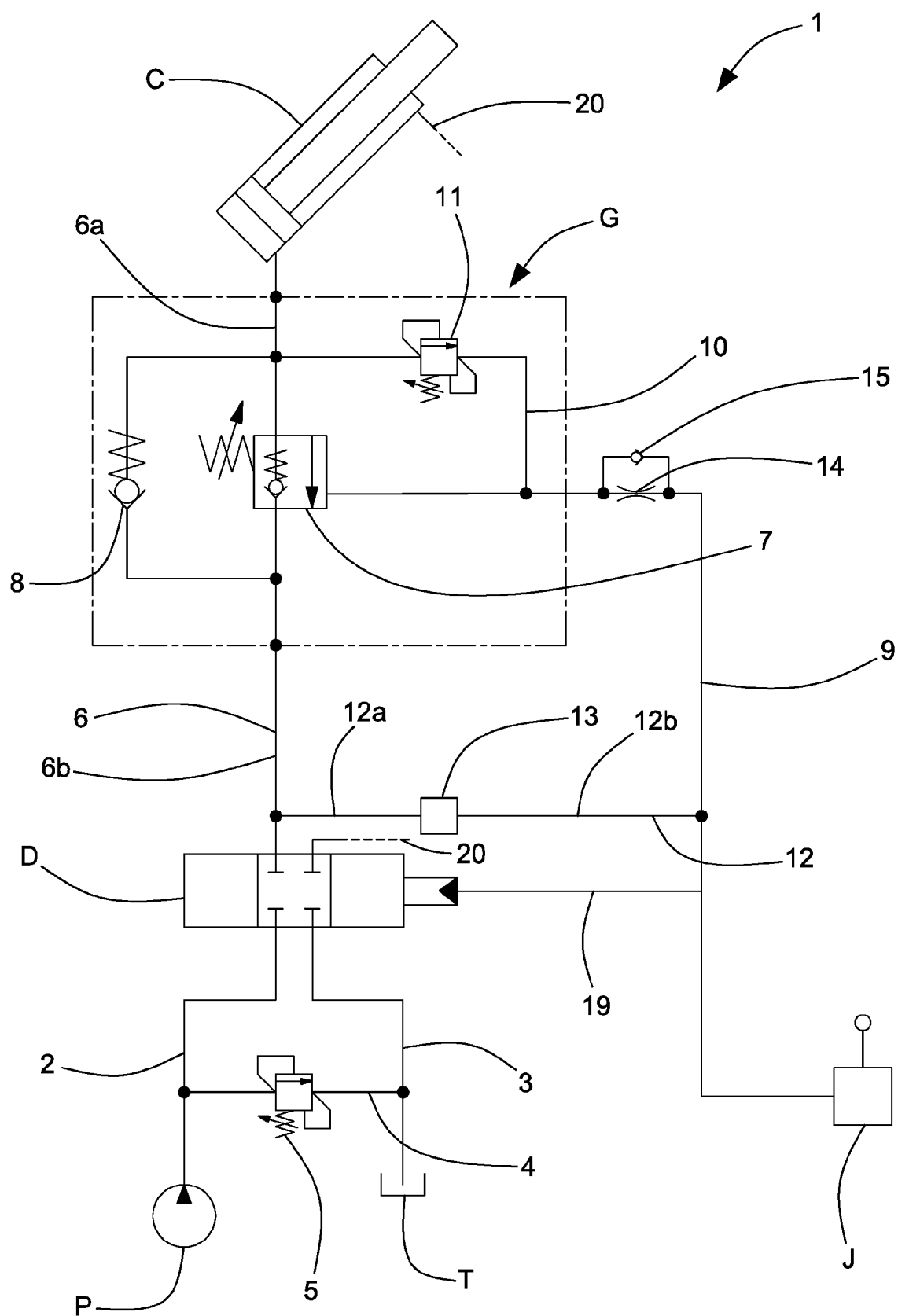


Fig. 4

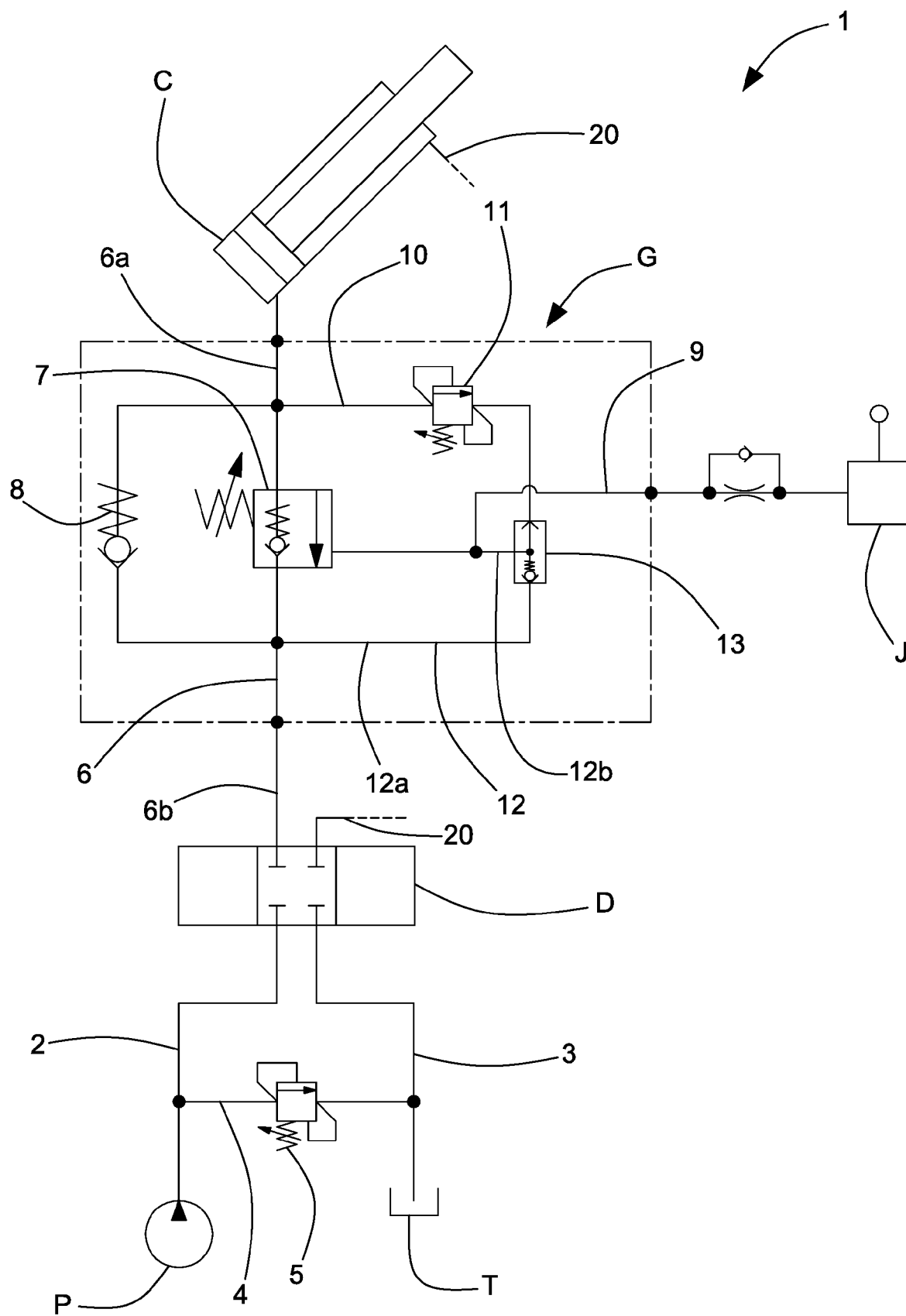


Fig. 5

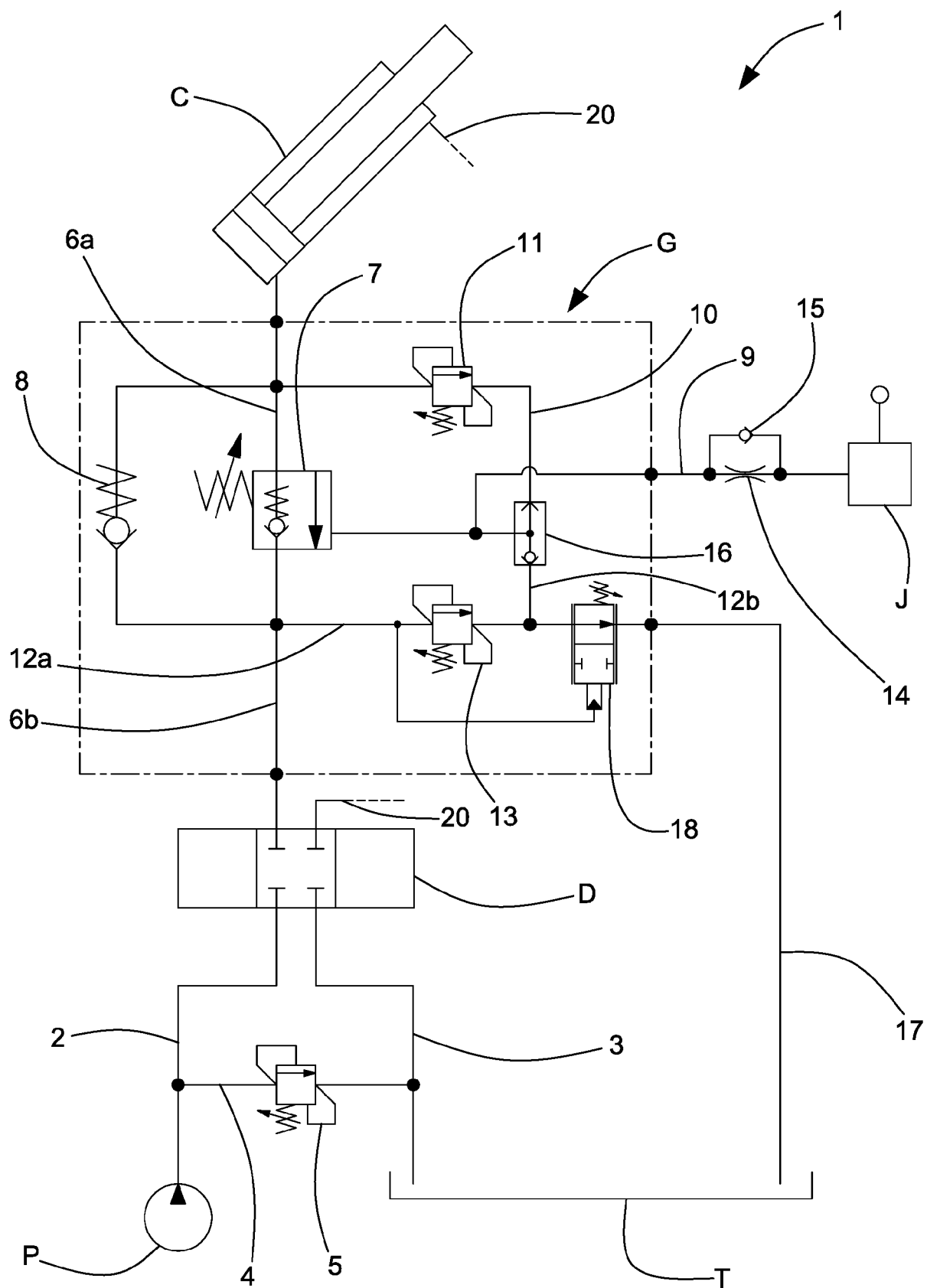


Fig. 6

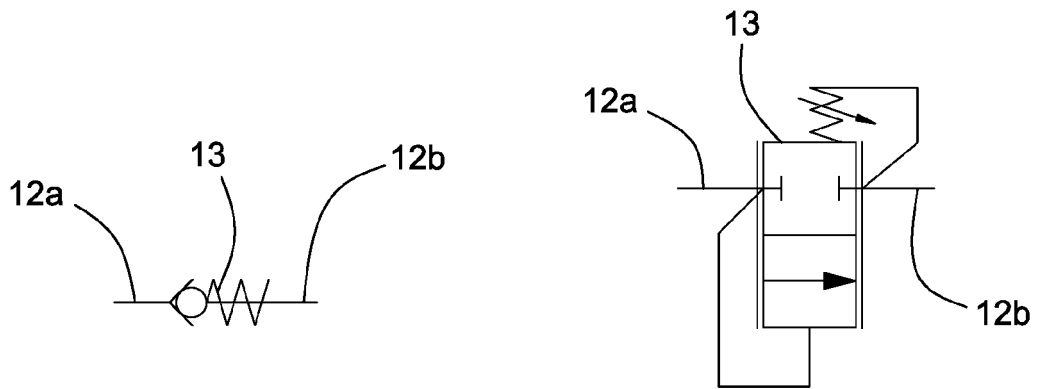


Fig. 7

Fig. 8

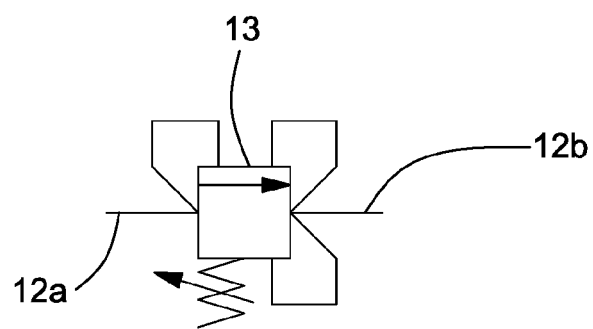


Fig. 9

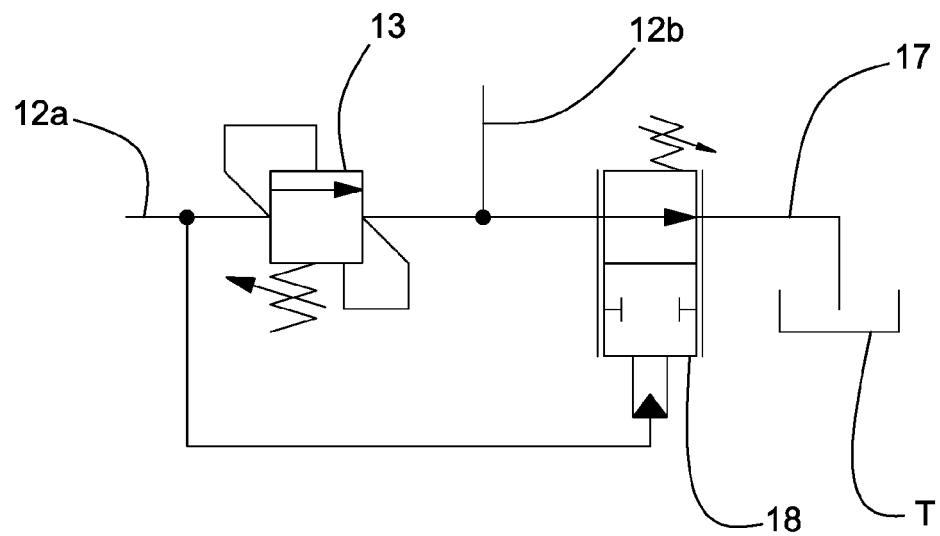


Fig. 10

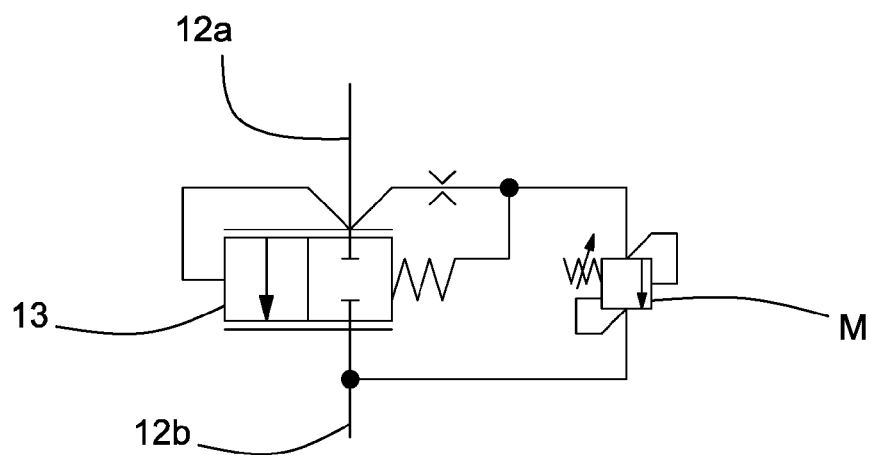


Fig. 11

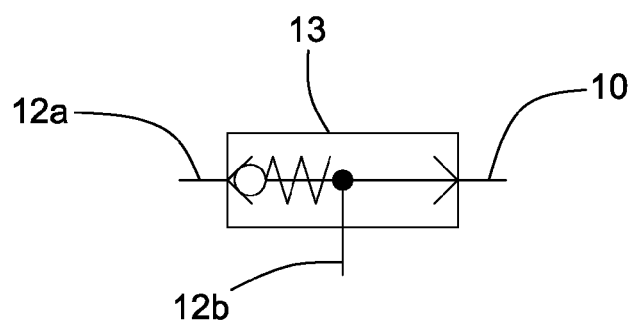


Fig. 12

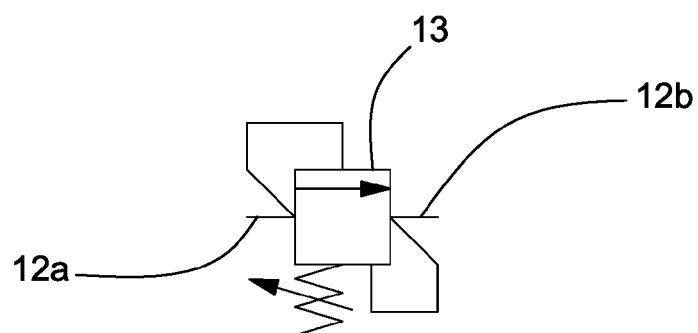


Fig. 13



EUROPEAN SEARCH REPORT

Application Number
EP 19 18 6852

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 4 936 032 A (MARCON LOUIS [FR] ET AL) 26 June 1990 (1990-06-26)	1,2,4, 11,12	INV. F15B11/00
A	* column 2, line 38 - column 3, line 42; figures 1-3 *	3,5-10	F15B21/00
Y	EP 3 312 436 A1 (ATLANTIC FLUID TECH S R L [IT]) 25 April 2018 (2018-04-25)	1,2,4, 11,12	
A	* paragraph [0063]; figure 6 * * paragraph [0069] * * paragraph [0022] - paragraph [0034]; figure 7 *	3,5-10	
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	* paragraph [0025] - paragraph [0049]; figures 1-5 *		
			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 December 2019	Examiner Díaz Antuña, Elena
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 19 18 6852

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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