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(71) Applicant: **Brevini Fluid Power S.P.A.**
42100 Reggio Emilia (RE) (IT)

(72) Inventors:
- **Bartoli, Maurizio**
42123 Reggio Emilia (IT)
- **Fasano, Stefano**
42124 Reggio Emilia (IT)

(74) Representative: **Villanova, Massimo et al**
Luppi Crugnola & Partners S.r.l.
Viale Corassori, 54
41124 Modena (IT)

(54) **Control device**

(57) A control device comprises a hydraulic circuit having a main line (3) that delivers an operating fluid to a single-acting hydraulic actuator (2) that drives a lifting apparatus in which a load-bearing support is connected to the actuator by at least one motion-transmitting member; on the main line a flow control valve, a pressure compensating element (11) and at least one check valve (12) operate to support the motion-transmitting member; the check valve is opened by a pressure signal in the main line; the load-bearing support will advantageously descend at a relatively high speed when unloaded, ensuring reduced pressure loss on the fluid-discharge circuit.

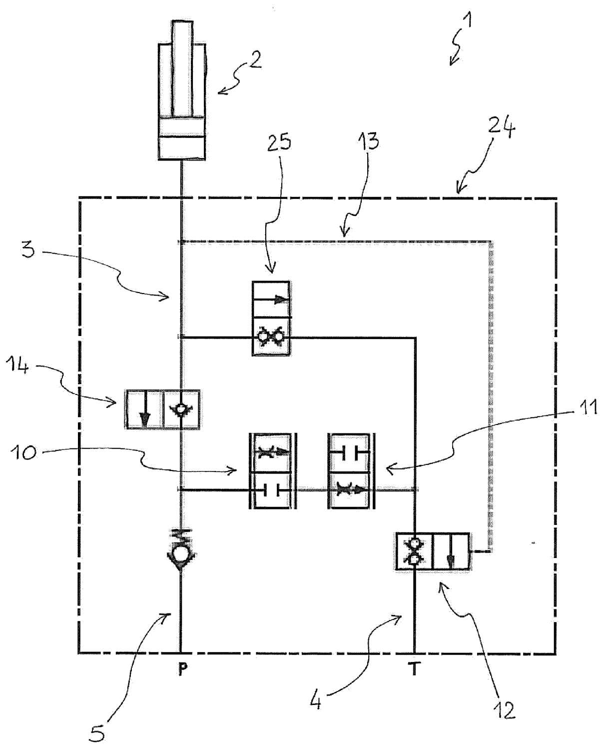

Fig. 1

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Description

Background of the invention

[0001] The invention relates to a control device, in particular for a hydraulic lifting apparatus having a hydraulic actuator configured for the ascent and descent of a movable load-bearing support connected directly or indirectly to the actuator by means of at least one traction or motion-transmitting member.

[0002] Specifically, but not exclusively, the invention can be applied to a residential elevator or to a lifting platform, or to a hoist, or to a forklift truck, in which a load-bearing support, for example a load-bearing platform, is moved vertically by a linear hydraulic actuator by means of a transmission system of the tension flexible member type (for example with cable/s or chain/s) that are in general used to multiply the stroke of the load-bearing support with respect to that of the movable element of the actuator.

[0003] US 5,040,639 shows a device according to the preamble of the first claim.

[0004] A lifting apparatus is already known, in particular a home lift, which is driven by a single-acting linear hydraulic actuator, with a vertical axis, provided with a system of cables that is able to develop a set multiplication ratio (generally a ratio of 2: 1). The hydraulic control device of the actuator comprises a flow-direction control valve for supporting the load and, when required, a further check valve (cable-supporting valve) arranged on a hydraulic discharge line for supporting the system of cables, in particular during a step when the loading-supporting platform of the lifting apparatus is parked unloaded. This known cable-supporting valve is piloted to close by a spring calibrated (for example to about 7-8 bar) to the pressure required to counter at least the weight of the system of cables that lies on the piston of the hydraulic lifting cylinder.

[0005] The cable-supporting valve reduces the risk of disengagement of the cables from the pulleys, or in general, disengagement from the lifting member, in particular when the load-bearing platform of the lifting apparatus stops on a mechanical stop, the weight of the platform no longer pressing on the lifting system, in a position in which the piston of the hydraulic cylinder has not generally reached the end of the stroke. In the absence of the cable-supporting valve, the cable could lose tension and consequently the appropriate condition of engagement in the pulley. A platform reascent step could be impossible because of disengagement of the cables.

[0006] However, adopting the cable-supporting valve, calibrated, for example to 7-8 bar, entails the drawback of an increase in the pressure differential ΔP that is necessary for correct operation of the device. There will, in particular, be the undesired consequence of a reduced stroke speed of the load-bearing platform, for example the descent speed of the unloaded platform.

[0007] The control devices for lifting apparatuses of the aforementioned type thus need to meet two opposing needs: preventing in certain operating steps that the flexible members disengage from the respective rotatable elements with which they are coupled, and, at the same time, permitting a relatively high speed of the load-bearing support, in particular during the unloaded descent step.

Summary of the invention

[0008] One object of the invention is to provide a control device that is able to overcome one or more of the aforementioned limits and drawbacks.

[0009] One advantage is to devise a control device, for a hydraulic actuator of a lifting apparatus, that is able to prevent a traction or motion transmission member that supports the load-bearing support of the lifting apparatus disengaging from the element with which it is coupled.

[0010] One advantage is to provide a control device for the movable element of an actuator of a lifting apparatus in which the movable element can move at a relatively high speed in any operating situation, in particular also in an unloaded descent step of the load-bearing support of the apparatus.

[0011] One advantage is to make available a constructionally simple and cheap device.

[0012] One object of the invention is to devise a hydraulic lifting apparatus driven by the aforesaid control device.

[0013] Such objects and advantages, and still others, are achieved by the device, by the apparatus and by use according to one or more of the claims set out below.

[0014] In one example, the control device comprises a hydraulic circuit having a main line arranged for sending an operating fluid to a single-acting hydraulic actuator that drives a lifting apparatus in which a load-bearing support is connected to the actuator by at least one motion-transmitting member (for example a tension flexible member); the main line may have a flow adjusting valve and/or a pressure compensating element and/or an emergency valve (on/off valve) for the operations of emergency lowering of the lifting apparatus; the main line may further have at least one check valve to support the motion-transmitting member; the check valve/s is/are piloted to open by a pressure signal (which may be detected and optionally processed) that is present in the main line.

Brief description of the drawings

[0015] The invention can be better understood and implemented with reference to the attached drawings that illustrate some embodiments thereof by way of non-limiting example.

[0016] Figure 1 is a diagram of a first embodiment of the control device according to the invention.

[0017] Figure 2 is a diagram of a second embodiment of the control device according to the invention.

[0018] Figure 3 is a diagram of a third embodiment of the control device according to the invention.

[0019] Figure 4 is a diagram of a fourth embodiment of the control device according to the invention.

[0020] Figure 5 is a diagram of a lifting apparatus that uses the control device.

Detailed description

[0021] With reference to the aforesaid figures, with 1 a control device has been indicated overall, in particular for controlling a hydraulic actuator 2.

[0022] In the attached figures, similar elements have been indicated with the same numbering, for the sake of simplicity.

[0023] With 3 a main hydraulic line has been indicated, with 4 a discharge line (T), with 5 an inlet for the connection (P) to the hydraulic delivery of a pump, with 10 a flow control valve (proportional valve), with 11 a pressure-compensating element, with 12 a check valve (called also, in certain cases, a cable-supporting valve) piloted to open by a pressure signal, or possibly by an electric, pneumatic or mechanical control.

[0024] With 13 a piloting line has been indicated that is suitable for generating a pressure signal (detected) on the main line 3. The piloting line 13 may be used (see figure 2) to detect, by one or more pressure transducers, a pressure signal located on the main line 3. This pressure signal may be optionally processed by an electric or electronic device 30.

[0025] With 14 a valve has been indicated for controlling the direction of the flow for supporting the load, with 25 an emergency valve, or seal on/off valve to permit the emergency lowering manoeuvres, with 24 an (optional) block has been indicated that (at least partially) integrates the components listed above.

[0026] The control device 1 comprises a hydraulic circuit having the main line 3 and the discharge line 4 (leading into the discharge T) that branches off from the main line 3.

[0027] The main line 3 has an inlet end arranged on the inlet 5 for connecting to a hydraulic delivery (P) of a pump, and an actuator end arranged for connecting to the hydraulic actuator 2 to command lifting of a movable element of the actuator 2.

[0028] The inlet 5 of the pressurised fluid has the task of supplying pressurised fluid to drive the hydraulic actuator 2.

[0029] The hydraulic actuator 2 will be connected to the actuator end of the main line 3. The actuator 2 will have a movable element (piston) that is liftable by driving a pump that, in turn, will be driven by an (electric) motor.

[0030] The discharge line 4 will be arranged for connecting to a discharge (T) to enable a descent of the movable element. In the specific example, the discharge, defined by the symbol (T), may be connected to a tank (of known type and non-illustrated).

[0031] The control device 1 may be used, in particular, to control a lifting apparatus 7 (figure 5), in particular a home lift.

[0032] The lifting apparatus 7 may comprise, for example, a load-bearing support 8 that ascends and descends, and the hydraulic linear actuator 2 arranged for driving the lifting of the load-bearing support 8. In the specific case, the load-bearing support 8 comprises a lift compartment, in particular of a home lift, but it is possible to provide for this support comprising, for example, the platform of a lift, or the forks of a forklift truck, or the support of a hoist, etc. The actuator 2 may be of the single-acting type and may have an operating chamber and a movable element (piston).

[0033] The lifting apparatus 7 may comprise, in particular, winch means 9 for connecting the movable element of the actuator 2 to the load-bearing support 8. The winch means 9 will have at least one tension flexible member (cable) for supporting the load-bearing support 8. The winch means is of known type and is therefore only schematised in the figure 5.

[0034] The hydraulic circuit of the control device 1 will be connected to the operating chamber of the single-acting hydraulic cylinder 2. The main line 3 will be connected, by the inlet 5, to a pump for controlling (in an ascent step of the support 8) lifting of the movable element. The discharge line 4 may be connected to the tank to enable (during the support 8 descent step) the movable element of the actuator to be lowered.

[0035] The control device 1 may comprise, as in this embodiment, the flow control valve 10, or proportional valve (in the case in point an electric proportional valve), arranged on the discharge line 4 for controlling a flow of operating fluid.

[0036] The control device 1 may further comprise, for example, the pressure compensating element 11, arranged on the discharge line 4 for controlling a flow of operating fluid from the main line 3 to the discharge, through the discharge line 4.

[0037] The pressure compensating element 11 ensures, in particular, that the movable element (piston) of the actuator 2 can keep the set speed constant in any load situation of the load-bearing support, in particular both fully loaded and unloaded.

[0038] The control device 1 may comprise, for example, the emergency valve 25 (on/off valve) for the emergency descent manoeuvres.

[0039] The control device 1 may comprise, for example, the check valve 12 (cable-supporting valve), arranged on the discharge line 4 to enable a flow to the discharge. The check valve 12 may be arranged between the (proportional) flow control valve 10 and the discharge (T) and/or between the pressure compensating element 11 and the discharge (T) and/or in each point of the line of the circuit traversed by the fluid during the step of descent of the load-bearing support or of the lifting system. In particular, the check valve 12 (cable-supporting valve) may be piloted to close by elastic means. In the specific case, the check valve 12 is calibrated, by regulating the compression of the elastic means, at a calibrating pressure comprised, for example, between 0 and 15 bar, in particular between 0 and 7 bar.

[0040] The control device 1 may comprise, for example, the piloting line 13, arranged in such a manner that the check valve 12 (cable-supporting valve) is piloted to open by a piloting pressure coming substantially from the main line 3 and/or from a circuit zone arranged upstream of the flow control valve 10, where "upstream" means on the valve side facing the main line 3.

[0041] The control device 1 may comprise the flow direction control valve 14, arranged in a main line 3 portion comprised between the aforesaid actuator end of the line 3 and a branch zone from which the discharge line 4 branches off. The flow direction control valve 14 may have, in particular, a first position in which it prevents the flow to the branching zone and permits the flow in the opposite direction. The flow control valve 14 may have, for example, a second position in which it permits the flow to the branching zone. In particular, the flow direction control valve 14 may be a valve commanded to the aforesaid second position by an electric command (for example induction by solenoid) or by any other command, for example hydraulic, pneumatic, manual or mechanical.

[0042] The piloting line 13 may have, as in this embodiment, an end terminating in any zone of the main line 3, for example between the flow direction control valve 14 and the actuator end of the line 3.

[0043] The control device 1 may further comprise (figure 4) a pressure limiting valve 16 arranged on a first safety line that branches off the main line 3 and is directed to the discharge.

[0044] The device 1 may comprise (figure 4) an auxiliary discharge line that branches off from the main line 3 and joins the discharge line 4. An emergency valve 25, or on/off valve, (manually operated), may be arranged on the auxiliary discharge line.

[0045] The check valve 12 (cable-supporting valve) will be calibrated by adjusting compression of the elastic means to a preset calibrating pressure to enable the minimum load to be supported, which is determined by the lifting apparatus when the load-bearing support 8 stops on a mechanical stop, the weigh of the load-bearing support 8 no longer lying on the lifting apparatus, in a position in which the piston of the hydraulic cylinder has not generally reached the end of the stroke. This minimum lying load will comprise at least the weight of the winch means 9 (for example cable/s and pulley/s). The check valve 12 will thus have the function of supporting at least the load of the winch means 9, so the check valve 12 may be called a cable-supporting valve. This check valve 12 (which in one embodiment may be piloted by a piloting pressure taken from the main line 3) enables a relatively reduced pressure difference Δp to be obtained in the discharge line 4, and consequently, a high-speed descent of the unloaded load-bearing support 8.

[0046] The control device 1 may comprise an integrated block 24 (indicated by a dashed line) that includes inside at least one part of the hydraulic circuit of the device. In particular, the block 24 integrates at least the flowrate adjusting proportional valve 10, at least the flow direction control valve 14 for supporting the load-bearing support (this valve 14, or equivalent element that is able to perform the function thereof, could also be included in the proportional valve 10), the cable-supporting check valve 12 and, optionally, the pressure-compensating element 11.

[0047] In use, the main line 3, which arrives at the linear hydraulic actuator 2 on the piston side, will be connected with the pump (which will in turn be coupled with a motor, for example an electric motor). The other lines of the hydraulic circuit may be connected to the tank that acts as a discharge.

[0048] The (cable supporting) check valve 12 may be piloted by the pressure taken from the main line 3 upstream of the proportional valve 10. Alternatively, it is possible to take the piloting pressure of the cable-supporting check valve 12 at any point of the circuit (in particular, line 3 or line 4) traversed by the fluid during the load-bearing support descent step or lifting apparatus descent step.

[0049] Below, the operation of the control device 1 and of the lifting apparatus 7 is disclosed. Operation may be controlled by an electronic controller on the basis of a preset procedure.

[0050] There is an initial step, which precedes the start-up proper, in which the flow control proportional valve 10 (in this case electric) is supplied electrically so that it reaches a maximum opening condition. Following the powering up of the valve 10, the pump starter motor is started.

[0051] Thus at the start of the start-up, the entire flowrate of operating fluid supplied by the pump is directed to the discharge through the discharge line 4.

[0052] The valve 10 (electric proportional valve) is then gradually closed. Whilst the valve 10 is being closed the flowrate of operating fluid is distributed between the discharge line 4 and the main line 3, gradually increasing the fraction that flows to the main line 3 and thus to the actuator 2, consequently decreasing what flows in the discharge line 4, causing an increase in the speed of the actuator 2.

[0053] The proportional valve 10 may be controlled in such a manner as to maintain an operating fluid flow rate through the discharge line 4 (bleed flow) that is such that the movable element of the actuator 2 reaches maximum permitted speed. In this manner, the movable element of the actuator can move at a speed that is substantially constant and the same as or very near the maximum permitted or desired speed.

[0054] The ascent speed of the load-bearing support 8 finishes with the stop at the floor: in order to accomplish the stop at the floor, the proportional valve 10 is reopened, causing a drop in speed.

[0055] The descent step of the load-bearing support 8 occurs with the motor switched off, through the force of gravity. In the initial descent step, the proportional valve 10 is shut, is then gradually opened, to thus enable the flow to move towards the discharge 4, in this step the fluid also passes through the check valve 12 (cable-supporting valve), which is kept open by the piloting command.

[0056] The diagram in figure 5 shows in a simplified manner the connection between the movable element (in particular the stem of the piston) of the actuator 2 and the tension flexible member (cable) of the winch means 9, and the connection between the flexible member and the support 8 (lifting platform). The arrangement of the winch means 9 can permit, for example, a 2:1 ratio between the stroke of the load-bearing support 8 and the stroke of the movable element of the actuator 2.

[0057] In the lifting apparatus 7, by virtue of the special control device adopted, there is no risk of an impediment in the process of reascent of the support 8 due to the disengagement of the cables from the respective pulleys. Further, the pressure difference Δp in the control device that is due to the cable-supporting check valve 12, is relatively reduced, so that there can be relatively high speeds, for example also during the unloaded descent step.

[0058] In fact, the cable-supporting check valve 12 is piloted to open by using the pressure present in the main line, upstream of the valve 10. Thus the cable-supporting check valve 12 remains completely open when a relatively low pressure value is reached in the operating chamber of the actuator. In this manner there is the advantage of obtaining a relatively high descent speed of the unloaded support 8.

Claims

1. Control device comprising:

- at least one main line (3) of hydraulic circuit and at least one discharge line (4) that branches out from said main line, said main line having an inlet end (5) arranged for connecting with a hydraulic delivery and an actuator end arranged for connecting with a hydraulic actuator (2) to command lifting of a movable element of the actuator, said discharge line being arranged for connecting to a discharge to enable the movable element to descend;
- a proportional flow control valve (10) arranged on said discharge line (4) for controlling a flow of operating fluid;
- at least one pressure compensator element (11) arranged on said discharge line (4) for enabling a flow from said main line (3) to the discharge to be controlled;
- at least one check valve (12) to permit a flow to the discharge, said check valve being arranged between said actuator end and said discharge at a hydraulic circuit point along which the fluid flows during a descend of the movable element of the actuator, said check valve (12) being piloted to close at least by elastic means;
- piloting means (13) for piloting said check valve (12) to open on the basis of a piloting pressure substantially present in said main line (3);

characterized in that said at least one check valve (12) is arranged on said discharge line (4).

2. Device according to claim 1, wherein said piloting means comprises sensor means for detecting the piloting pressure and a control device (30) configured to receive a signal from said sensor means and to pilot said check valve (12), e.g. by means of an electric, pneumatic, or mechanic control, on the basis of the received signal.

3. Device according to claim 1 or 2, wherein said piloting means comprises a piloting line (13) arranged for piloting to open said check valve (12) by the piloting pressure coming substantially from said main line (3).

4. Device according to any preceding claim, wherein said check valve (12) is arranged between said proportional valve (10) and the discharge (T) and/or between said pressure compensator element (11) and the discharge (T).

5. Device according to any preceding claim, comprising a flow direction control valve (14) for holding up a load on the actuator, said flow direction control valve (14) being arranged in a portion of said main line (3) comprised between said actuator end and a branch from which said discharge line (4) branches off.

6. Device according to claim 5, said flow direction control valve (14) having a first position in which it prevents the flow to said branch and permits the flow in an opposite direction, and a second position in which it permits the flow to said branch.

7. Device according to claim 5 or 6, said flow direction control valve (14) being piloted to said second position by an electric, hydraulic, pneumatic, mechanic, or manual command.

8. Device according to any preceding claim, wherein said piloting means comprises a piloting line (13) having an end terminating in said main line between said proportional flow control valve (10) and said actuator end.

9. Device according to any preceding claim, wherein said piloting means comprises a piloting line (13) having an end terminating in said main line (3) between said compensator element (11) and said actuator end.

10. Device according to any preceding claim, wherein said check valve (12) is calibrated by regulating the compression of said elastic means, e.g. at a calibrating pressure comprised between 0 and 15 bar.

11. Device according to any preceding claim, comprising an emergency valve (25) arranged on the hydraulic circuit between said actuator end and said check valve (12) to enable a load on the actuator to be held up during an emergency descent.

12. Lifting apparatus comprising:

- a load-bearing support (8) that is movable up and down;
- a hydraulic actuator (2) that is arranged for driving the lifting of said support, said actuator being single-effect and having an operating chamber and a movable element;
- connecting means (9) for connecting said hydraulic actuator (2) to said load-bearing support (8), said connecting means having at least one motion transmission member for supporting said load-bearing support (8);
- a control device for controlling said hydraulic actuator (2), said control device being made according to any preceding claim.

13. Use of a control device according to any one of claims 1 to 11 to control a lifting apparatus, in particular a lifting apparatus according to claim 12, said lifting apparatus having a movable load-bearing support (8) connected to a hydraulic actuator (2) by connecting means (9), said check valve (12) being calibrated, by regulation of the compression of said elastic means, at a set calibration pressure to enable the connecting means of the load-bearing support (8) to be supported, in particular if the load-bearing support (8) stops on a mechanic stroke end - before the movable element of the hydraulic actuator (2) comes to the end of stroke - with its weight weighing on no longer on the lifting means.

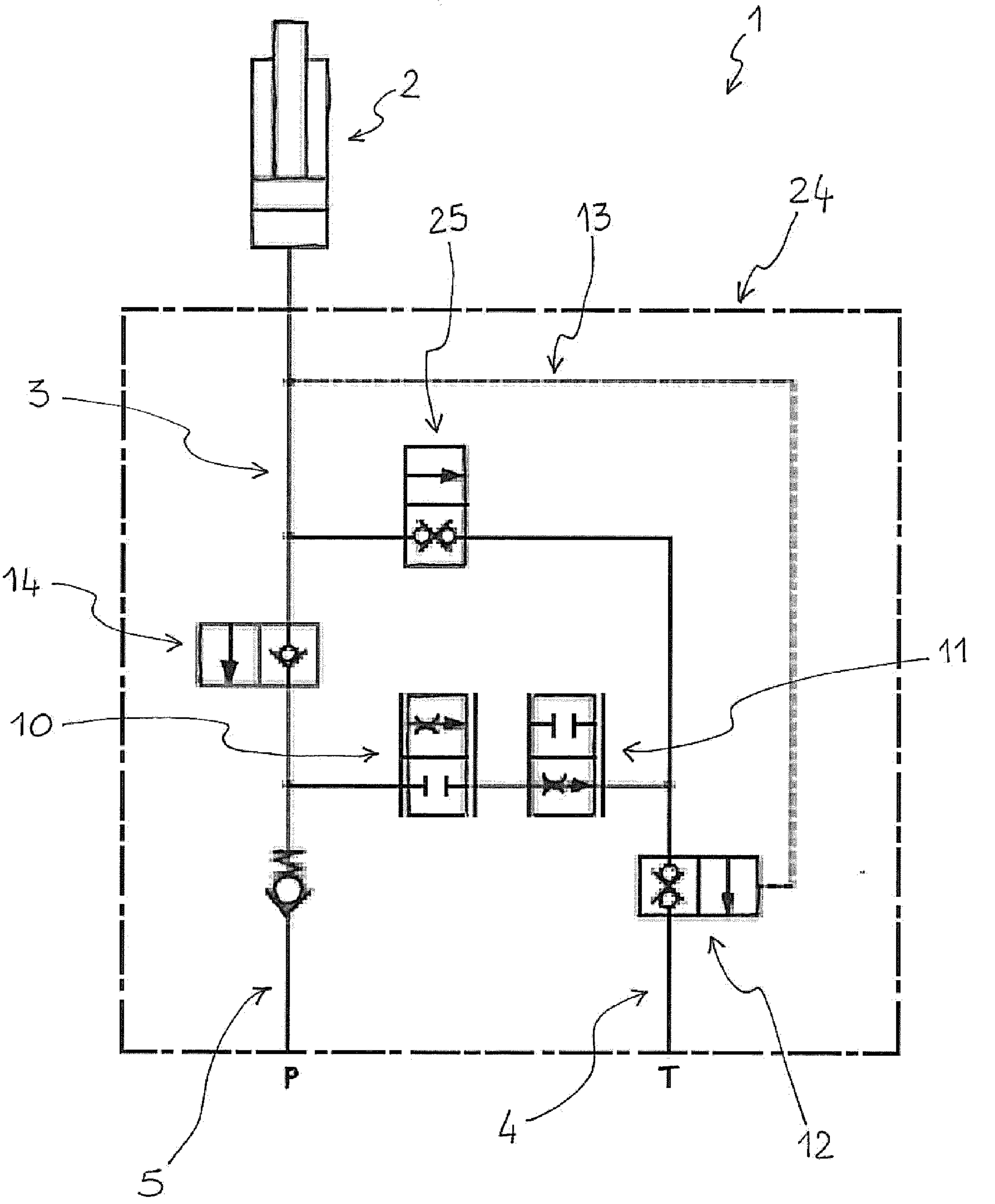

Fig. 1

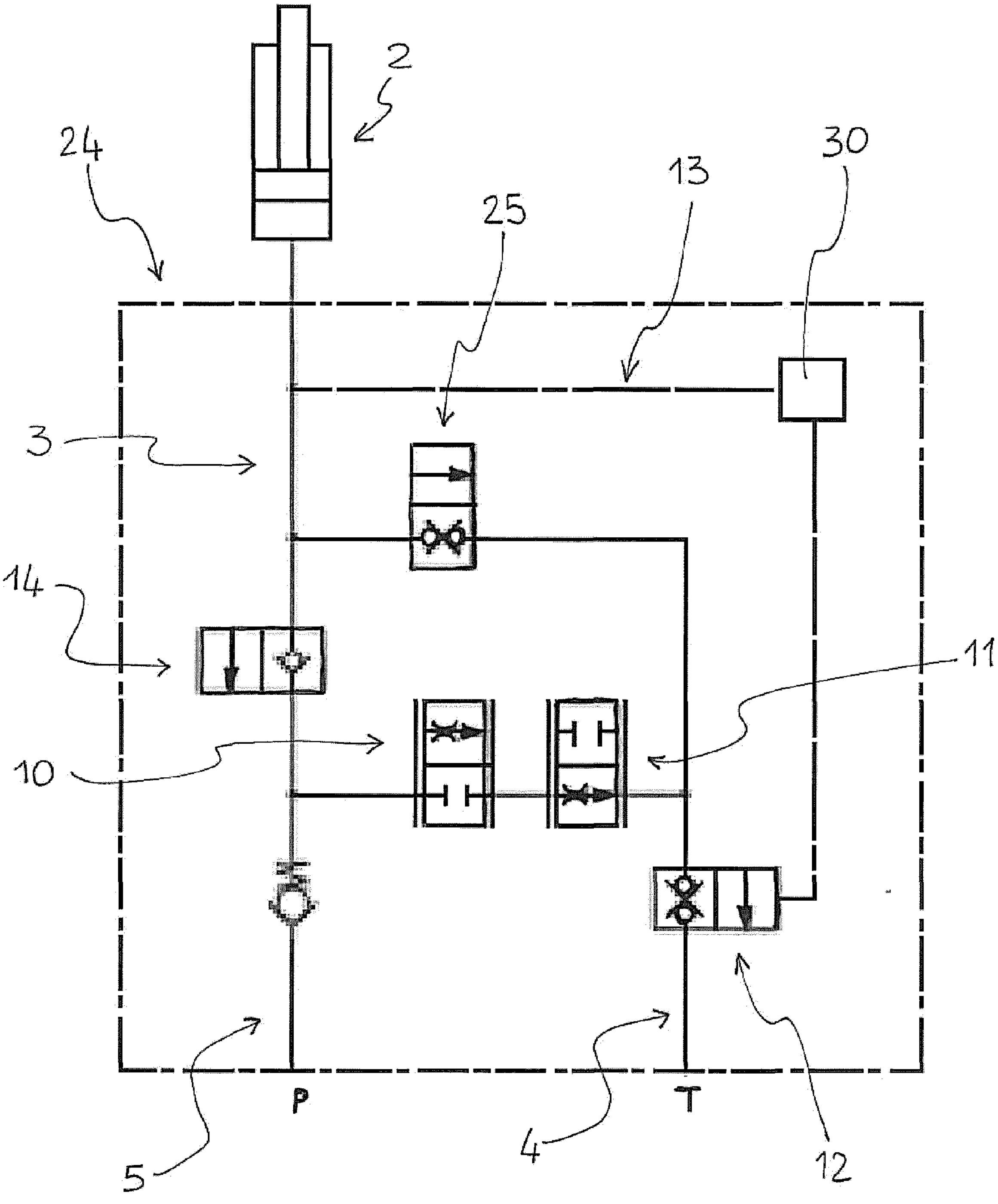

Fig. 2

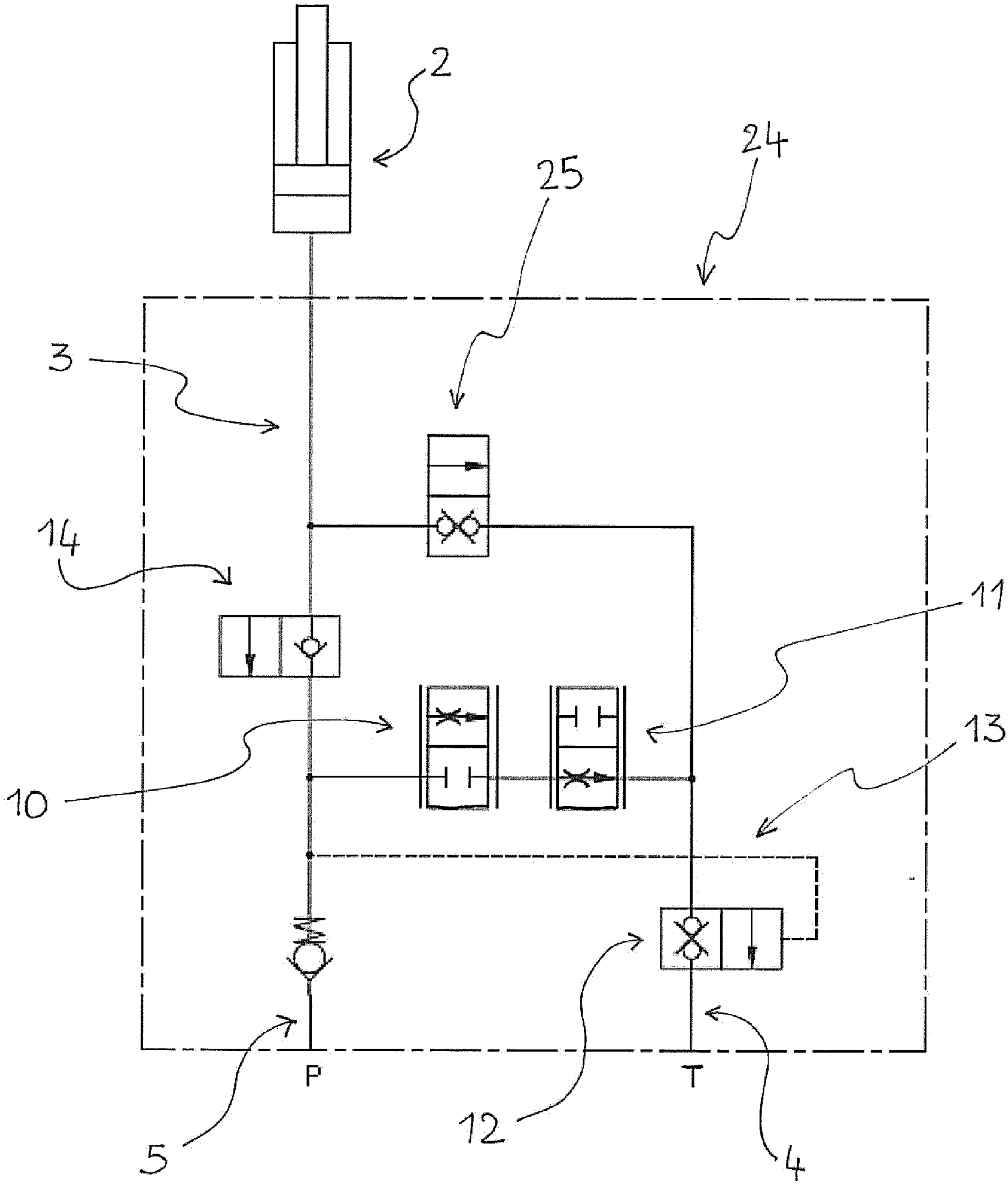

Fig. 3

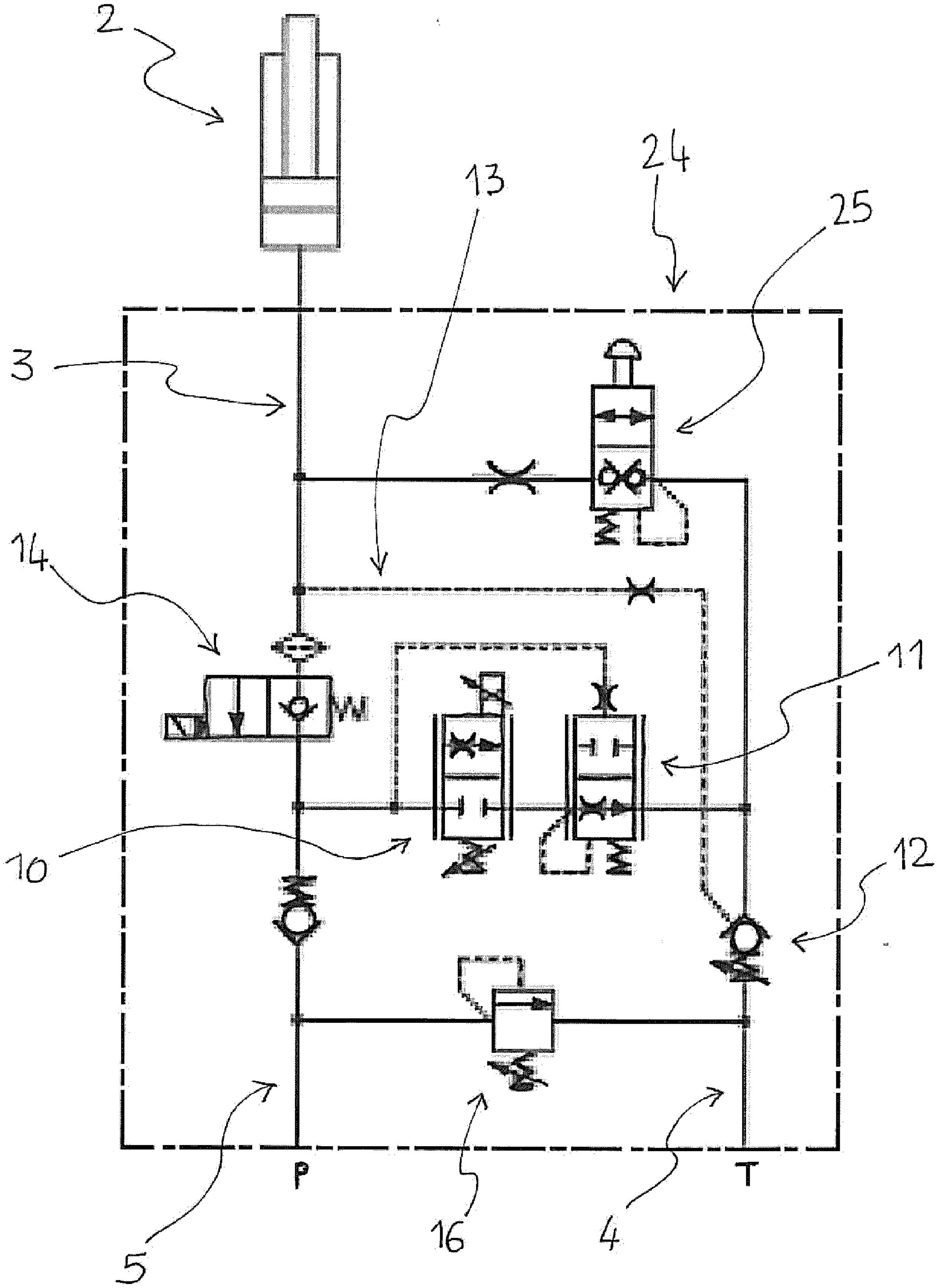

Fig. 4

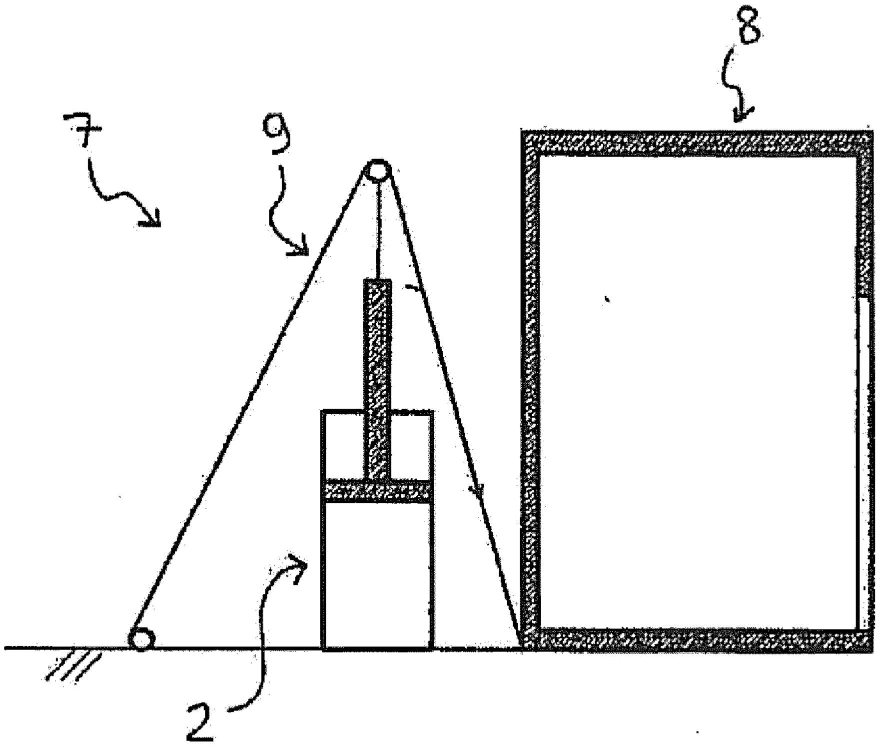

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 5040639 A **[0003]**