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DESCRIPTION

TECHNICAL FIELD

[0001] Embodiments of the present invention relate to a valve and a hydraulic system with the same.

[0002] A valve according to the preamble of claim 1 is known, for example, from WO 2007/090522 A1, DE 26 49 775 A1 or DE 30 14 202 A1.

BACKGROUND

[0003] Generally, a conventional counterbalance valve is disposed in a hydraulic system as a separate valve.

SUMMARY

[0004] An object of embodiments of the present invention is to provide a valve in which a counterbalance valve is integrated.

[0005] This object is solved with a valve according to claim 1.

[0006] According to the embodiments of the present invention, the counterbalance valve is integrated in the valve.

[0007] Embodiments of the present invention further provide a hydraulic system comprising: the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic sectional view of a valve in a state where a main valve spool is in a middle main valve spool position according to an embodiment of the present invention, which is taken along a first axial section of the valve;

FIG. 2 is a schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position according to the embodiment of the present invention, which is taken along a second axial section of the valve rotated through about 45 degrees

relative to the first axial section around an axis of the valve;

FIG. 3 is a schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position according to the embodiment of the present invention, which is taken along a third axial section of the valve rotated through about 90 degrees relative to the first axial section around the axis of the valve;

FIG. 4 is a schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position according to the embodiment of the present invention, which is taken along a fourth axial section of the valve rotated through about 135 degrees relative to the first axial section around the axis of the valve;

FIG. 5 is a schematic diagram of a hydraulic system according to an embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position, taken along the first axial section of the valve;

FIG. 6 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position, taken along the second axial section of the valve;

FIG. 7 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position, taken along the third axial section of the valve;

FIG. 8 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the middle main valve spool position, taken along the fourth axial section of the valve;

FIG. 9 is a schematic sectional view of the valve in a state where the main valve spool is in a second main valve spool position according to the embodiment of the present invention, which is taken along the first axial section of the valve;

FIG. 10 is a schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position according to the embodiment of the present invention, which is taken along the second axial section of the valve;

FIG. 11 is a schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position according to the embodiment of the present invention, which is taken along the third axial section of the valve;

FIG. 12 is a schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position according to the embodiment of the present invention, which is taken along the fourth axial section of the valve;

FIG. 13 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position, taken along the first axial section of the valve;

FIG. 14 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position, taken along the second axial section of the valve;

FIG. 15 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position, taken along the third axial section of the valve;

FIG. 16 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the second main valve spool position, taken along the fourth axial section of the valve;

FIG. 17 is a schematic sectional view of the valve in a state where the main valve spool is in a first main valve spool position according to the embodiment of the present invention, which is taken along the first axial section of the valve;

FIG. 18 is a schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position according to the embodiment of the present invention, which is taken along the second axial section of the valve;

FIG. 19 is a schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position according to the embodiment of the present invention, which is taken along the third axial section of the valve;

FIG. 20 is a schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position according to the embodiment of the present invention, which is taken along the fourth axial section of the valve;

FIG. 21 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position, taken along the first axial section of the valve;

FIG. 22 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position, taken along the second axial section of the valve;

FIG. 23 is a schematic diagram of the hydraulic system according to the embodiment of the

present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position, taken along the third axial section of the valve; and

FIG. 24 is a schematic diagram of the hydraulic system according to the embodiment of the present invention, which shows the schematic sectional view of the valve in the state where the main valve spool is in the first main valve spool position, taken along the fourth axial section of the valve.

DETAILED DESCRIPTION

[0009] As shown in FIGS. 1-24, a valve 100 according to an embodiment of the present invention includes: a valve casing 1, a main valve spool 2 and a counterbalance valve spool 3. The valve casing 1 includes: a valve casing body 1B, a main valve bore 1C extending in an axial direction in the valve casing body 1B; and a first working port (for example a port A) 30, a second working port (for example a port B) 34, a supply port (for example a port P) S and a return port (for example a port T) R formed in the valve casing body 1B (referring to FIG.4). The main valve spool 2 is disposed in the main valve bore 1C of the valve casing 1 and is slidable in the main valve bore 1C to change the communication status between each of the first and second working ports 30 and 34 and each of the supply and return ports S and R, and the main valve spool 2 includes: a main valve spool body 2B, a main valve spool internal cavity 2C extending in the axial direction in the main valve spool body 2B; a main valve spool wall 2W surrounding the main valve spool internal cavity 2C; an inlet passage 17 which passes through the main valve spool wall 2W in a direction crossing the axial direction and which is configured for the second working port 34; and an outlet passage TP which passes through the main valve spool wall 2W in a direction crossing the axial direction and which has an inlet TP1 towards the main valve spool internal cavity 2C and an outlet TP2 towards the valve casing body 1B (referring to FIG.2). The counterbalance valve spool 3 is disposed in the main valve spool internal cavity 2C of the main valve spool 2 and is slidable between a first counterbalance valve spool position (i.e. the position shown in FIGS. 1-16) and a second counterbalance valve spool position (i.e. the position shown in FIGS. 17-24). The counterbalance valve spool 3 includes: a counterbalance valve spool body 3B; and a first counterbalance valve spool recess 23 formed on an outer periphery of the counterbalance valve spool body 3B. In a state where the counterbalance valve spool 3 is in the first counterbalance valve spool position, the inlet TP1 of the outlet passage TP of the main valve spool 2 is closed by the counterbalance valve spool 3; and in a state where the counterbalance valve spool 3 is in the second counterbalance valve spool position, the inlet TP1 of the outlet passage TP of the main valve spool 2 is opened by the counterbalance valve spool 3 through the first counterbalance valve spool recess 23 of the counterbalance valve spool 3, so that the second working port 34 is in communication with the return port R through the inlet passage 17 configured for the second working port 34, the first counterbalance valve spool recess 23 and

the outlet passage TP. Thereby, a hydraulic fluid (for example hydraulic oil) from the second working port 34 enters the return port R through the inlet passage 17 configured for the second working port 34, the first counterbalance valve spool recess 23 and the outlet passage TP by being throttled by the outlet passage TP (referring to FIG. 19) . The counterbalance valve spool 3 and the main valve spool 2 constitute a counterbalance valve. The valve 100 may be a load sensing valve or a load sensing multiple valve. The first counterbalance valve spool recess 23 is configured to supply a fluid to the counterbalance valve. The inlet passage 17 may extend in a radial direction of the main valve spool body 2B. The main valve spool body 2B may have a substantially cylindrical shape. A second working port inlet throttling groove 18 (as shown in FIG. 1) is in communication with the inlet passage 17. The first counterbalance valve spool recess 23 may be an annular recess surrounding the outer periphery of the counterbalance valve spool body 3B, or a recess extending along a portion, in a peripheral or circumferential direction, of the outer periphery of the counterbalance valve spool body 3B. A chamber is formed by the first counterbalance valve spool recess 23 and an inner wall of a second main spool internal cavity 2C2 of the main valve spool body 2B. The outlet passage TP may extend substantially in the radial direction of the main valve spool body 2B. The outlet passage TP may be a throttling passage. The valve 100 may be a hydraulic control valve or the like.

[0010] As shown in FIGS. 1-24, according to an embodiment of the present invention, the supply port S includes a first supply port 31 and a second supply port 33, and the return port R includes a first return port 29 and a second return port 36 (referring to FIG. 4). The main valve spool 2 is slidable among a first main valve spool position (i.e. the position shown in FIGS. 17-24), a middle main valve spool position (i.e. the position shown in FIGS. 1-8) and a second main valve spool position (i.e. the position shown in FIGS. 9-16) to change the communication status between the first working port 30 and each of the first supply port 31 and first return port 29, and the communication status between the second working port 34 and each of the second supply port 33 and second return port 36. In a state where the main valve spool 2 is in the first main valve spool position (i.e. the position shown in FIGS. 17-24), the first working port 30 is in communication with the first supply port 31, the counterbalance valve spool 3 is in the second counterbalance valve spool position (i.e. the position shown in FIGS. 17-24), and the second working port 34 is in communication with the second return port 36 through the inlet passage 17 configured for the second working port 34, the first counterbalance valve spool recess 23 and the outlet passage TP (referring to FIG. 19). Thereby, a hydraulic fluid (for example the hydraulic oil) from the second working port 34 enters the second return port 36 through the inlet passage 17 configured for the second working port 34, the first counterbalance valve spool recess 23 and the outlet passage TP by being throttled by the outlet passage TP. In a state where the main valve spool 2 is in the middle main valve spool position (i.e. the position shown in FIGS. 1-8), the counterbalance valve spool 3 is in the first counterbalance valve spool position (i.e. the position shown in FIGS. 1-16), and the first working port 30 and the second working port 34 are disconnected from the first supply port 31 and the second supply port 33, respectively. In a state where the main valve spool 2 is in the second main valve spool position (i.e. the position shown in FIGS. 9-16), the counterbalance valve spool 3 is in the first counterbalance valve spool position (i.e. the position shown in FIGS. 1-16), the first working

port 30 is in communication with the first return port 29, and the second working port 34 is in communication with the second supply port 33. The first supply port 31 and the second supply port 33 may be in communication with each other, and the first return port 29 and the second return port 36 may be in communication with each other. In the figures, T denotes an oil tank, and A and B denote the port A and the port B, respectively. The first supply port 31, the second supply port 33, the first return port 29, the second return port 36, the first working port (for example the port A) 30, and the second working port (for example the port B) 34 may be formed by recesses formed on an inner wall of the main valve bore 1C of the valve casing body 1B. Each of the recesses may be formed on all or part of a circumference of the inner wall of the main valve bore 1C of the valve casing body 1B in a circumferential direction. In the embodiment, the main valve spool 2 is slidable among the first main valve spool position, the middle main valve spool position and the second main valve spool position to control the communications and the non-communications between the working ports and the supply and return ports S and R. However, the main valve spool 2 may switch between two main valve spool positions or among four or more main valve spool positions to control communications and non-communications between working ports and supply and return ports S and R.

[0011] As shown in FIGS. 1-24, according to an embodiment of the present invention, the outlet passage TP includes a plurality of sub-outlet passages 24, 28 and 35 (as shown in FIGS. 6, 7 and 8) arranged in the axial direction, such that the greater a distance which the counterbalance valve spool 3 slides in a direction from the first counterbalance valve spool position towards the second counterbalance valve spool position is, the more sub-outlet passages 24, 28 and 35 are opened, and thus the greater a total flow area of these opened sub-outlet passages is (Referring to FIGS. 18-20 and 22-24). In this case, the second working port 34 is in communication with the first counterbalance valve spool recess 23 through the inlet passage 17 configured for the second working port 34. For example, the sub-outlet passages 24, 28 and 35 may be two, three or more sub-outlet passages. The outlet passage TP may be one outlet passage TP, or two or more outlet passages TP in substantially the same axial position, and each of the sub-outlet passages 24, 28 and 35 may be one sub-outlet passage, or two or more sub-outlet passages in substantially the same axial position. The inlet passage 17 configured for the second working port 34 may be one inlet passage 17, or two or more inlet passages 17 in substantially the same axial position. The sub-outlet passages 24, 28 and 35 may be sub-throttling passages.

[0012] As shown in FIGS. 17-24, according to an embodiment of the present invention, the main valve spool internal cavity 2C of the main valve spool 2 includes: first and second main valve spool internal cavities 2C1 and 2C2 extending in the axial direction in the main valve spool body 2B; a main valve spool internal cavity partition wall 2P between the first and second main valve spool internal cavities 2C1 and 2C2; a main valve spool internal cavity partition wall through hole 9 formed in the main valve spool internal cavity partition wall 2P and communicating the first main valve spool internal cavity 2C1 with the second main valve spool internal cavity 2C2; and a counterbalance valve spring cavity 20 extending from the second main valve spool internal cavity 2C2 in a direction away from the first main valve spool internal cavity 2C1. The counterbalance valve spool 3 is disposed in the second main valve spool

internal cavity 2C2 of the main valve spool 2, and has a first end 3E1 adjacent to the main valve spool internal cavity partition wall 2P of the main valve spool 2, and a second end 3E2 opposite to the first end 3E1. The valve 100 further includes: a counterbalance valve spring seat 4 disposed in the counterbalance valve spring cavity 20 of the main valve spool 2 and having an end 4E facing towards the counterbalance valve spool 3; and counterbalance valve springs 5 and 6 disposed in the counterbalance valve spring cavity 20 of the main valve spool 2 and configured to apply a force to the counterbalance valve spring seat 4 to bias the counterbalance valve spring seat 4 towards the counterbalance valve spool 3, so that the end 4E of the counterbalance valve spring seat 4 abuts against the second end 3E2 of the counterbalance valve spool 3 and applies a pushing force to the counterbalance valve spool 3 in a direction from the second counterbalance valve spool position towards the first counterbalance valve spool position. The main valve spool internal cavity partition wall through hole 9 may be a damping hole, or any other appropriate through hole. The main valve spool internal cavity partition wall through hole 9 may extend substantially in the axial direction. Although the two counterbalance valve springs 5 and 6 are shown in the figures, a single counterbalance valve spring may be used. An opening pressure of the counterbalance valve is determined by the counterbalance valve springs 5 and 6. The damping hole may be configured to reduce an impact pressure when the counterbalance valve is opened. The first end 3E1 may have a shape of a truncated cone.

[0013] As shown in FIGS. 17-24, according to an embodiment of the present invention, the main valve spool 2 further includes a first working port pressure acquisition hole 21 (as shown in FIG. 18) which passes through the main valve spool wall 2W of the main valve spool 2 in a direction crossing the axial direction. In the state where the main valve spool 2 in the main valve bore 1C is in the first main valve spool position, the first working port pressure acquisition hole 21 communicates the first working port 30 with the first main valve spool internal cavity 2C1 of the main valve spool 2. The first working port pressure acquisition hole 21 is configured to acquire a pressure value of the first working port 30 in operation. The first working port pressure acquisition hole 21 may extend substantially in the radial direction of the main valve spool body 2B.

[0014] As shown in FIGS. 17-24, according to an embodiment of the present invention, the main valve spool 2 further includes a second working port pressure acquisition hole (for example a load sensing (LS) pressure acquisition hole for the port B) 8 (as shown in FIG. 17) which passes through the main valve spool wall 2W of the main valve spool 2 in a direction crossing the axial direction. In the state where the main valve spool 2 in the main valve bore 1C is in the first main valve spool position, the second working port pressure acquisition hole 8 communicates the counterbalance valve spring cavity 20 with the second return port 36. The second working port pressure acquisition hole 8 is configured to acquire a size of a pressure value of the second working port 34 in operation. The second working port pressure acquisition hole 8 may extend obliquely to the axial direction.

[0015] As shown in FIGS. 17-24, especially as shown in FIG. 17, according to an embodiment of the present invention, the counterbalance valve spring seat 4 includes: a head 4H having

the end 4E facing towards the counterbalance valve spool 3; and a rod 4S inserted into the counterbalance valve springs, and the main valve spool 2 further includes a plug 7 which closes an end of the main valve spool internal cavity 2C of the main valve spool 2, and which is configured to restrict, by an abutment against the rod 4S of the counterbalance valve spring seat 4, a distance which the counterbalance valve spring scat 4 slides, and thus a distance which the counterbalance valve spool 3 slides in a direction from the first counterbalance valve spool position towards the second counterbalance valve spool position. Thereby, guiding of the springs can be improved, and a position of the counterbalance valve spool can also be controlled more accurately, preventing the counterbalance valve spool from moving out of a normal operating range due to a pressure fluctuation so that a load is abruptly stopped.

[0016] As shown in FIGS. 17-24, according to an embodiment of the present invention, the counterbalance valve spring cavity 20 of the main valve spool 2 has a greater cross-sectional size than the second main spool internal cavity 2C2. In the state where the main valve spool 2 in the main valve bore 1C is in the first main valve spool position, the counterbalance valve spool 3 is in the second counterbalance valve spool position so that the second end 3E2 of the counterbalance valve spool 3 enters the counterbalance valve spring cavity 20, and the counterbalance valve spring cavity 20 is in communication with the second return port 36 through a gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, a gap between the counterbalance valve spool 3 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, and the second working port pressure acquisition hole 8. Specifically, according to an embodiment of the present invention, the counterbalance valve spring seat 4 further includes: a counterbalance valve spring seat recess 25 (as shown in FIGS. 17 and 18) formed at an end surface of the end 4E on an outer periphery of the end 4E. The counterbalance valve spring cavity 20 is in communication with the second return port 36 through the gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, the gap between the counterbalance valve spool 3 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, the counterbalance valve spring seat recess 25, and the second working port pressure acquisition hole 8. For example, each of the first main valve spool internal cavity 2C1, the second main valve spool internal cavity 2C2 and the counterbalance valve spring cavity 20 may have a circular cross section. The counterbalance valve spring seat recess 25 may be an annular recess surrounding the outer periphery of the counterbalance valve spring seat 4, or a recess extending along a portion, in a peripheral or circumferential direction, of the outer periphery of the counterbalance valve spring seat 4. A chamber is formed by the counterbalance valve spring seat recess 25 and the inner wall of the counterbalance valve spring cavity 20. A diameter of the second end 3E2 of the counterbalance valve spool 3 may be less than or equal to a diameter of a bottom of the counterbalance valve spring seat recess 25.

[0017] As shown in FIGS. 17-24, according to an embodiment of the present invention, the valve casing 1 further includes a working port pressure detection cavity 32 (as shown in FIG. 17 and 20) formed in the valve casing body 1B, and the main valve spool 2 further includes a

first working port pressure feedback hole 26 (as shown in FIG. 19) which passes through the main valve spool wall 2W of the main valve spool 2 in a direction crossing the axial direction. In the state where the main valve spool 2 in the main valve bore 1C is in the first main valve spool position, the first working port pressure feedback hole 26 communicates the first main valve spool internal cavity 2C1 with the working port pressure detection cavity 32 so that the working port pressure detection cavity 32 is in communication with the first working port 30 through the first working port pressure feedback hole 26, the first main valve spool internal cavity 2C1 and the first working port pressure acquisition hole 21 (as shown in FIG. 18). The first working port pressure feedback hole 26 may be configured to feed back a pressure acquired by the first working port pressure acquisition hole 21 to the working port pressure detection cavity 32. The working port pressure detection cavity (for example an LS chamber) 32 is configured to feed back the pressure to a pump. The first working port pressure feedback hole 26 may extend substantially in the radial direction of the main valve spool body 2B. The working port pressure detection cavity 32 may be formed by a recess formed on the inner wall of the main valve bore 1C of the valve casing body 1B. The recess may be formed on all or part of the circumference of the inner wall of the main valve bore 1C of the valve casing body 1B in the circumferential direction.

[0018] As shown in FIGS. 1-24, according to an embodiment of the present invention, the valve 100 further includes a connection hole extending in the axial direction in an end of the main valve spool body 2B, for example a connection hole extending from the first main valve spool internal cavity 2C1 in a direction away from the second main valve spool internal cavity 2C2. The valve 100 further includes a biasing assembly configured to apply a force to the main valve spool 2 so as to bias the main valve spool 2 towards the middle main valve spool position. The biasing assembly includes a supporting shaft 13 (for example a hook) (such as shown in FIGS. 1 and 17). One end of the supporting shaft 13 is connected to an end of the main valve spool body 2B of the main valve spool 2. For example, the one end of the supporting shaft 13 is connected to the end of the main valve spool body 2B of the main valve spool 2 by inserting the one end of the supporting shaft 13 in the connection hole of the main valve spool body 2B. The biasing assembly further includes: a first main valve spool spring seat and a second main valve spool spring seat. Each of the first main valve spool spring seat and the second main valve spool spring seat includes a sleeve, and a flange disposed at an end of the sleeve. The biasing assembly further includes a main valve spool spring 11. The first main valve spool spring seat and the second main valve spool spring seat are fitted over the supporting shaft 13 to be slidable with respect to the supporting shaft 13. The sleeves of the first main valve spool spring seat and the second main valve spool spring seat are inserted into the main valve spool spring 11 from two ends of the main valve spool spring 11, respectively, such that the flanges of the first main valve spool spring seat and the second main valve spool spring seat abut against the two ends of the main valve spool spring 11, respectively. The other end of the supporting shaft 13 has a shoulder. An inner diameter of each of the flanges of the first main valve spool spring seat and the second main valve spool spring seat is less than an outer diameter of the main valve spool body 2B, and an outer diameter of each of the flanges of the first main valve spool spring scat and the second main valve spool spring scat is greater than a diameter of the main valve bore 1C of the valve casing body 1B of the valve casing 1.

Thereby, the first main valve spool spring seat and the second main valve spool spring seat are constrained between the shoulder of the supporting shaft 13 and an end surface of the valve casing body 1B of the valve casing 1. The second main valve spool spring seat adjacent to the shoulder of the supporting shaft 13 is fixed in the axial direction.

[0019] As shown in FIGS. 1-24, especially as shown in FIGS. 1 and 17, according to an embodiment of the present invention, the main valve spool 2 further includes: a first working port return throttling groove 14 formed in the main valve spool body 2B and configured to control a magnitude of a flow rate of a fluid flowing from the first working port 30 to the first return port 29; an inlet passage 17 configured for the second working port 34 and serving as an inlet of the counterbalance valve; a second working port inlet throttling groove 18 configured to control a magnitude of a flow rate of a fluid flowing from the second supply port 33 to the second working port 34; and a first working port inlet throttling groove 19 configured to control a magnitude of a flow rate of a fluid flowing from the first supply port 31 to the first working port 30. An annular groove is formed on an outer periphery of the main valve spool body 2B, the first working port return throttling groove 14 is in communication with the annular groove on one side of the annular groove, and the first working port inlet throttling groove 19 is in communication with the annular groove on the other side of the annular groove.

[0020] As shown in FIGS. 1-8, according to an embodiment of the present invention, in the state where the main valve spool 2 is in the middle main valve spool position, the first main valve spool internal cavity 2C1 and the counterbalance valve spring cavity 20 are in communication with the first return port 29 and the second return port 36, respectively. Specifically, as shown in FIG. 2, in the state where the main valve spool 2 is in the middle main valve spool position, the first working port pressure acquisition hole 21 communicates the first return port 29 with the first main valve spool internal cavity 2C1 of the main valve spool 2. In the state where the main valve spool 2 is in the middle main valve spool position, as shown in FIG.1, the second working port pressure acquisition hole 8 communicates the counterbalance valve spring cavity 20 with the second return port 36. For example, in the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the counterbalance valve spring cavity 20 is in communication with the second return port 36 through the gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, and the second working port pressure acquisition hole 8. In the embodiment shown in the figures, especially as shown in FIG.1, in the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the counterbalance valve spring cavity 20 is in communication with the second return port 36 through the gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, the counterbalance valve spring seat recess 25, and the second working port pressure acquisition hole 8.

[0021] As shown in FIGS. 1-8, especially as shown in FIGS. 1, 2 and 3, according to an embodiment of the present invention, in the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the first working port pressure

feedback hole 26 communicates the first main valve spool internal cavity 2C1 with the working port pressure detection cavity 32, and the first working port pressure acquisition hole 21 is in communication with the first return port 29, so that the working port pressure detection cavity 32 is in communication with the first return port 29 through the first working port pressure feedback hole 26, the first main valve spool internal cavity 2C1 and the first working port pressure acquisition hole 21.

[0022] As shown in FIGS. 1-8, especially as shown in FIG. 3, according to an embodiment of the present invention, the main valve spool 2 further includes a second working port pressure feedback hole 27 which passes through the main valve spool wall 2W of the main valve spool 2 in a direction crossing the axial direction. As shown in FIG. 3, the counterbalance valve spool 3 further includes: a counterbalance valve spool axial hole 15 which is formed in the counterbalance valve spool body 3B substantially in the axial direction; and a counterbalance valve spool communication hole 15C which is formed in the counterbalance valve spool body 3B in a direction crossing the axial direction and which is in communication with the counterbalance valve spool axial hole 15. The counterbalance valve spool communication hole 15C may be in communication with the second working port pressure feedback hole 27 through a second counterbalance valve spool recess 22 formed on the outer periphery of the counterbalance valve spool body 3B. The counterbalance valve spring scat 4 further includes: a counterbalance valve spring seat groove 16 (as shown in FIG.1) formed at an end surface of the end 4E and extending in a direction crossing the axial direction. In the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the second working port pressure feedback hole 27 communicates the counterbalance valve spool axial hole 15 with the working port pressure detection cavity 32 through the counterbalance valve spool communication hole 15C, and the second working port pressure acquisition hole 8 communicates the counterbalance valve spool axial hole 15 with the second return port 36 through the counterbalance valve spring seat groove 16, so that the working port pressure detection cavity 32 is in communication with the second return port 36 through the second working port pressure feedback hole 27, the counterbalance valve spool communication hole 15C, the counterbalance valve spool axial hole 15, the counterbalance valve spring seat groove 16 and the second working port pressure acquisition hole 8, as shown in FIGS. 1 and 3. The second working port pressure feedback hole 27 may be configured to feed back a pressure acquired by the second working port pressure acquisition hole 8 to the working port pressure detection cavity 32. For example, the counterbalance valve spring seat groove 16 may extend on the end surface of the end 4E such that an end of the counterbalance valve spring seat groove 16 extends to an edge of the end surface of the end 4E, so that the counterbalance valve spring seat groove 16 is in communication with the counterbalance valve spring scat recess 25. The counterbalance valve spring scat groove 16 is in communication with the counterbalance valve spool axial hole 15. The end 4E of the counterbalance valve spring seat 4 abuts against the second end 3E2 of the counterbalance valve spool 3. A sealing contact may be formed between the end surface of the end 4E of the counterbalance valve spring seat 4 and an end surface of the second end 3E2 of the counterbalance valve spool 3. The second working port pressure feedback hole 27 may extend substantially in the radial direction of the main valve spool body 2B, as shown in FIG. 3.

[0023] As shown in FIGS. 1-8, according to an embodiment of the present invention, the counterbalance valve spring seat groove 16 communicates the counterbalance valve spool axial hole 15 with the counterbalance valve spring seat recess 25 formed in the outer periphery of the end 4E of the counterbalance valve spring seat 4. As shown in FIGS. 1 and 3, in the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the second working port pressure feedback hole 27 communicates the counterbalance valve spool axial hole 15 with the working port pressure detection cavity 32 through the counterbalance valve spool communication hole 15C, and the second working port pressure acquisition hole 8 communicates the counterbalance valve spool axial hole 15 with the second return port 36 through the counterbalance valve spring seat recess 25 and the counterbalance valve spring seat groove 16, so that the working port pressure detection cavity 32 is in communication with the second return port 36 through the second working port pressure feedback hole 27, the counterbalance valve spool communication hole 15C, the counterbalance valve spool axial hole 15, the counterbalance valve spring seat groove 16, the counterbalance valve spring seat recess 25 and the second working port pressure acquisition hole 8. The counterbalance valve spring seat recess 25 may be configured to feed back a load sensing (LS) pressure.

[0024] As shown in FIGS. 1-8, especially as shown in FIGS. 1 and 3, according to an embodiment of the present invention, the counterbalance valve spool 3 further includes: the second counterbalance valve spool recess 22 formed on the outer periphery of the counterbalance valve spool body 3B. The counterbalance valve spool communication hole 15C communicates the second counterbalance valve spool recess 22 with the counterbalance valve spool axial hole 15. In the state where the main valve spool 2 in the main valve bore 1C is in the middle main valve spool position, the second working port pressure feedback hole 27 is in communication with the counterbalance valve spool communication hole 15C through the second counterbalance valve spool recess 22. The second counterbalance valve spool recess 22 may be configured to feed back a load sensing (LS) pressure. The second counterbalance valve spool recess 22 may be an annular recess surrounding the outer periphery of the counterbalance valve spool body 3B, or a recess extending along a portion, in the peripheral or circumferential direction, of the outer periphery of the counterbalance valve spool body 3B. A chamber is formed by the second counterbalance valve spool recess 22 and the inner wall of the second main spool internal cavity 2C2 of the main valve spool body 2B. An outer peripheral surface of the counterbalance valve spool body 3B is in sealing contact with a surface of the inner wall of the second main spool internal cavity 2C2.

[0025] According to an embodiment of the present invention, referring to FIGS. 9-16, in the state where the main valve spool 2 is in the second main valve spool position, the first main valve spool internal cavity 2C1 is in communication with the first return port 29. For example, as shown in FIG. 10, in the state where the main valve spool 2 is in the second main valve spool position, the first working port pressure acquisition hole 21 communicates the first return port 29 with the first main valve spool internal cavity 2C1 of the main valve spool 2. According to an embodiment of the present invention, referring to FIGS. 9-16, especially as shown in FIG.

9, in the state where the main valve spool 2 is in the second main valve spool position, the second working port pressure acquisition hole 8 communicates the counterbalance valve spring cavity 20 with the second working port 34. For example, as shown in FIG. 9, in the state where the main valve spool 2 in the main valve bore 1C is in the second main valve spool position, the counterbalance valve spring cavity 20 is in communication with the second working port 34 through the gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, and the second working port pressure acquisition hole 8. In the example shown in FIGS. 9-16, especially as shown in FIG. 9, in the state where the main valve spool 2 in the main valve bore 1C is in the second main valve spool position, the counterbalance valve spring cavity 20 is in communication with the second working port 34 through the gap between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, the counterbalance valve spring seat recess 25, and the second working port pressure acquisition hole 8.

[0026] According to an embodiment of the present invention, referring to FIGS. 9-16, in the state where the main valve spool 2 in the main valve bore 1C is in the second main valve spool position, as shown in FIG. 11, the second working port pressure feedback hole 27 communicates the counterbalance valve spool axial hole 15 with the working port pressure detection cavity 32 through the counterbalance valve spool communication hole 15C, and as shown in FIG. 9, the second working port pressure acquisition hole 8 communicates the counterbalance valve spool axial hole 15 with the second working port 34 through the counterbalance valve spring seat groove 16, so that the working port pressure detection cavity 32 is in communication with the second working port 34 through the second working port pressure feedback hole 27, the counterbalance valve spool communication hole 15C, the counterbalance valve spool axial hole 15, the counterbalance valve spring seat groove 16 and the second working port pressure acquisition hole 8.

[0027] In the example shown in FIGS. 9-16, in the state where the main valve spool 2 in the main valve bore 1C is in the second main valve spool position, as shown in FIG. 11, the second working port pressure feedback hole 27 communicates the counterbalance valve spool axial hole 15 with the working port pressure detection cavity 32 through the counterbalance valve spool communication hole 15C, and as shown in FIG. 9, the second working port pressure acquisition hole 8 communicates the counterbalance valve spool axial hole 15 with the second working port 34 through the counterbalance valve spring seat recess 25 and the counterbalance valve spring seat groove 16, so that the working port pressure detection cavity 32 is in communication with the second working port 34 through the second working port pressure feedback hole 27, the counterbalance valve spool communication hole 15C, the counterbalance valve spool axial hole 15, the counterbalance valve spring seat groove 16, the counterbalance valve spring seat recess 25 and the second working port pressure acquisition hole 8.

[0028] According to an embodiment of the present invention, referring to FIGS. 9-16, especially as shown in FIGS. 9 and 11, in the state where the main valve spool 2 in the main

valve bore 1C is in the second main valve spool position, the second working port pressure feedback hole 27 may be in communication with the counterbalance valve spool communication hole 15C through the second counterbalance valve spool recess 22.

[0029] Embodiments of the present invention further provide a hydraulic system 200 including the valve 100. Referring to FIGS. 5-8,13-16 and 21-24, the hydraulic system 200 further includes: a hydraulic cylinder 41 which has chambers located on both sides of a piston of the hydraulic cylinder 41 and respectively connected with the first working port 30 and the second working port 34 (it can be understood that herein the hydraulic cylinder is merely an example of an actuator and any other actuator such as a motor may be used in the hydraulic system); a first working port overflow valve 42 connected with the first working port 30; a second working port overflow valve 40 connected with the second working port 34; a pump 37, such as a load sensing variable displacement pump, connected with the first supply port 31 and the second supply port 33 through a check valve 44; a shuttle valve 38 through which the working port pressure detection cavity 32 feeds back the pressure to a feedback port of the pump 37; and a pressure detection overflow valve (load sensing (LS) overflow valve) 39 connected with the feedback port of the pump 37.

[0030] An operational principle of the valve 100 and an operational principle of the hydraulic system 200 in the state where the main valve spool 2 is in the middle main valve spool position is described as below with reference to FIGS. 1-8.

[0031] Referring to FIGS. 1-8, in the state where the main valve spool 2 is in the middle main valve spool position, the first supply port 31 and the second supply port 33 are disconnected from the first working port 30 and the second working port 34, respectively. In this case, as shown in FIG. 5, on one side of the counterbalance valve spool 3, a pressure of the working port pressure detection cavity 32 is released to the second return port 36 sequentially through the second working port pressure feedback hole 27, the second counterbalance valve spool recess 22, the counterbalance valve spool axial hole 15, the counterbalance valve spring seat groove 16, the counterbalance valve spring seat recess 25 and the second working port pressure acquisition hole 8, thereby achieving a relief of the pressure of the working port pressure detection cavity 32. As shown in FIG. 5,on the other side of the counterbalance valve spool 3, the pressure of the working port pressure detection cavity 32 is released sequentially through the first working port pressure feedback hole 26, the first main valve spool internal cavity 2C1, and the first working port pressure acquisition hole 21, thereby achieving a relief of the pressure of the working port pressure detection cavity 32. Therefore, when the main valve spool 2 is in the middle main valve spool position, the pressure of the working port pressure detection cavity 32 is released to the first return port 29 and the second return port 36 on both sides of the working port pressure detection cavity 32. In this case, an operating state of the counterbalance valve is as follows.

1. (1) A pressure of the counterbalance valve spring cavity 20 is released to the second return port 36 sequentially through a fit clearance between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main

valve spool 2, the counterbalance valve spring seat recess 25, and the second working port pressure acquisition hole 8.

2. (2) In this case, the pressure of the first main valve spool internal cavity 2C1 is generally equal to a pressure of the first return port 29, so that the pressure of the first main valve spool internal cavity 2C1 cannot overcome a total spring force of the two springs 5 and 6 of the counterbalance valve. Therefore, in this case, the counterbalance valve spool 3 is in a stationary state in the first counterbalance valve spool position.
3. (3) The outlet TP2 of the sub-outlet passage 24 is in communication with the second return port 36, and the inlet TP1 of the sub-outlet passage 24 is closed by the counterbalance valve spool 3, as shown in FIG. 6.
4. (4) The outlet TP2 of the sub-outlet passage 28 is closed by the valve casing 1, and the inlet TP1 of the sub-outlet passage 28 is closed by the counterbalance valve spool 3, as shown in FIG. 7.
5. (5) The outlet TP2 of the sub-outlet passage 35 is in communication with the second return port 36, and the inlet TP1 of the sub-outlet passage 28 is closed by the counterbalance valve spool 3, as shown in FIG. 8.
6. (6) Therefore, when the main valve spool 2 is in the middle main valve spool position, all of the inlets TP1 of the sub-outlet passages 24, 28 and 35 are closed by the counterbalance valve spool 3, a fluid from the second working port 34 cannot flow to the second return port 36, and thus a load is retained.

[0032] The operational principle of the valve 100 and the operational principle of the hydraulic system 200 in the state where the main valve spool 2 is in the second main valve spool position is described as below with reference to FIGS. 9-16.

[0033] Referring to FIGS. 9-16, when the main valve spool 2 is in the second main valve spool position, the fluid flows from the second supply port 33 to the second working port 34 (port B). A magnitude of a flow rate of the fluid is adjustable by the second working port inlet throttling groove 18, and a direction of motion D of the piston of the hydraulic cylinder 41 is as shown in FIGS. 13-16. In this case, the second working port pressure acquisition hole 8 is in communication with the second working port 34 as shown in FIG. 13, so that a pressure of the second working port 34 is fed back to the working port pressure detection cavity 32 sequentially through the second working port pressure acquisition hole 8, the counterbalance valve spring scat recess 25, the counterbalance valve spring seat groove 16, the counterbalance valve spool axial hole 15, the counterbalance valve spool communication hole 15C, the second counterbalance valve spool recess 22, and the second working port pressure feedback hole 27, and is fed back to the pump 37 through the shuttle valve 38, thereby achieving a load sensing control. On the other hand, as shown in FIG. 15, the first working port pressure feedback hole 26 is disconnected from the working port pressure detection cavity 32, and as shown in FIG. 14, the first main valve spool internal cavity 2C1 is in communication with the first return port 29 through the first working port pressure acquisition hole 21 so that a pressure of the first main valve spool internal cavity 2C1 is released. In this case, the operating

state of the counterbalance valve is as follows.

1. (1) All of the outlets TP2 of the sub-outlet passage 24, the sub-outlet passage 28, and the sub-outlet passage 35 are in communication with the second working port 34. However, all of the inlets TP1 of the sub-outlet passages 24, 28 and 35 are closed by the counterbalance valve spool 3, as shown in FIGS. 14, 15 and 16.
2. (2) A load pressure of the second working port 34 is introduced to the counterbalance valve spring cavity 20 through the second working port pressure acquisition hole 8, and the fit clearance between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, as shown in FIG. 13. Therefore, in this case, a pressure of the counterbalance valve spring cavity 20 is equal to a pressure of the second working port 34.
3. (3) Since the pressure of the first main valve spool internal cavity 2C1 is generally equal to the pressure of the first return port 29, and the pressure of the counterbalance valve spring cavity 20 is equal to the pressure of the second working port 34, the counterbalance valve spool 3 is pressed in the main valve spool 2 and is in the stationary state in the first counterbalance valve spool position.

[0034] The operational principle of the valve 100 and the operational principle of the hydraulic system 200 in the state where the main valve spool 2 is in the first main valve spool position is described as below with rcfcrcncc to FIGS. 17-24.

[0035] Referring to FIGS. 17-24, when the main valve spool 2 is in the first main valve spool position, the hydraulic fluid flows from the first supply port 31 to the first working port 30 (port A), as shown in FIG. 17. A magnitude of a flow rate of the hydraulic fluid is adjustable by the first working port inlet throttling groove 19, and the direction of motion D of the piston of the hydraulic cylinder 41 is as shown in FIGS. 21-24. In this case, as shown in FIG. 18, a pressure of the first working port 30 is fed back to the working port pressure detection cavity 32 through the first working port pressure acquisition hole 21, the first main valve spool internal cavity 2C1, and the first working port pressure feedback hole 26, thereby achieving the load sensing control. The second working port pressure feedback hole 27 is disconnected from the working port pressure detection cavity 32, as shown in FIG. 19. In this case, the operating state of the counterbalance valve is as follows.

1. (1) The pressure of the counterbalance valve spring cavity 20 is released to the second return port 36 through the fit clearance between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, the counterbalance valve spring seat recess 25, and the second working port pressure acquisition hole 8, as shown in FIG. 17. Therefore, in this case, the pressure of the counterbalance valve spring cavity 20 is equal to a pressure of the second return port 36.
2. (2) The pressure of the first main valve spool internal cavity 2C1 is equal to the pressure of the first working port 30, and enters the second main valve spool internal cavity 2C2

through the main valve spool internal cavity partition wall through hole 9 such as the damping hole, as shown in FIG. 18, thereby opening the counterbalance valve against the total force of the counterbalance valve springs 5 and 6. In other words, the counterbalance valve spool 3 is moved to the second counterbalance valve spool position.

3. (3) During the movement of the counterbalance valve spool 3 to the second counterbalance valve spool position, a total flow area of the sub-throttling passages as the sub-outlet passages 24, 28 and 35 gradually increases. The hydraulic fluid from the second working port 34 flows from the sub-outlet passages 24, 28 and 35 to the second return port 36 through the inlet passage 17 configured for the second working port 34, and the first counterbalance valve spool recess 23, thereby achieving actions, such as lowering the negative load and forward tilting the negative load.
4. (4) The flow rate has a continuity. A ratio of a magnitude of a flow rate of the first working port 30 to an area of the piston of the hydraulic cylinder is in proportion to a ratio of a magnitude of a flow rate of the second working port 34 to the area of the piston of the hydraulic cylinder. Therefore, the flow rate is continuous. A magnitude of a flow rate of the hydraulic fluid passing through the counterbalance valve may be completely controlled by the first working port inlet throttling groove 19, thereby avoiding problems such as a stall or an uncontrollable flow rate caused by the negative load. In addition, a total area of the sub-outlet passages 24, 28 and 35 changes gradually, thereby achieving a soft start of a load and improving control performance.

[0036] With the valve according to the embodiments of the present invention, a counterbalance valve is integrated in a spool of a load sensing multiple valve. Thereby, a function of the counterbalance valve is achieved. In addition, a load sensing (LS) pressure is fed back to the working port pressure detection cavity 32 through the fit clearance between the counterbalance valve spring seat 4 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, and the fit clearance between the counterbalance valve spool 3 and the inner wall of the counterbalance valve spring cavity 20 of the main valve spool 2, thereby achieving both a load sensing function and the function of the counterbalance valve. Furthermore, an integrity level is greatly improved. Further, a required controlling pressure is successfully achieved in a narrow space by the two springs and the first end 3E1 of the counterbalance valve spool 3 having a shape of a truncated cone.

[0037] The valve according to the embodiments of the present invention may be applied to cranes, forklifts, and the like.

[0038] With the valve according to the embodiments of the present invention, the counterbalance valve is configured to control actions of a negative load of a hydraulic cylinder or a motor, such as lowering the negative load and forward tilting the negative load, so that a velocity of movement of the hydraulic cylinder or the motor is controllable, and a stable movement is achieved. Structurally, the counterbalance valve is disposed in the main valve

spool. Thereby, a structure of the valve is more compact while ensuring working performance, so that the valve is more suitable for a narrow mounting space.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

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Patentkrav

1. Ventil (100), der omfatter:

et ventilhus (1), der omfatter: et ventilhuslegeme (1B), en hovedventilboring (1C), der strækker sig i en aksial retning i ventilhuslegemet (1B), og en første arbejdsport (30), en anden arbejdsport (34), en tilførselsport (S), der omfatter en første tilførselsport (31) og en anden tilførselsport (33), og en returport (R), der omfatter en første returport (29) og en anden returport (36), som er dannet i ventilhuslegemet (1B),

en hovedventilspole (2), der er anbragt i ventilhusets (1B) hovedventilboring (1C), og som er forskydelig i hovedventilboringen (1C) med henblik på at ændre forbindelsesstatussen mellem hver af de første og anden arbejdsporte (30, 34) og hver af tilførsels- og returportene (S, R), idet hovedventilspolen (2) er forskydelig mellem en første hovedventilspoleposition, en midterste hovedventilspoleposition og en anden hovedventilspoleposition med henblik på at styre forbindelsesstatussen mellem den første arbejdsport (30) og hver af den første tilførselsport (31) og første returport (33), og forbindelsesstatussen mellem den anden arbejdsport (34) og hver af den anden tilførselsport (33) og anden returport (36), idet hovedventilspolen (2) omfatter:

et hovedventilspolelegeme (2B), et hovedventilspoleindrehulrum (2C), der strækker sig i den aksiale retning i hovedventilspolelegemet (2B),

en hovedventilspolevæg (2W), der omgiver hovedventilspoleindrehulrummet (2C),

en indløbspassage (17), der passerer gennem hovedventilspolevæggen (2W) i en retning, som krydser den aksiale retning, og som er konfigureret til den anden arbejdsport (34), og

en udløbspassage (TP), der passerer gennem hovedventilspolevæggen (2W) i en retning, som krydser den aksiale retning, og som har et indløb (TP1) mod hovedventilspoleindrehulrummet (2C) og et udløb (TP2) mod ventilhuslegemet (1B), og

en kontravægtsventilspole (3), der er anbragt i hovedventilspolens (2) hovedventilspoleindrehulrum (2C), og som er forskydelig i forhold til hovedventilspolen (2) mellem en første kontravægtventilspoleposition og en anden kontravægtventilspoleposition, idet kontravægtventilspolen (3) omfatter:

et kontravægtventilspolelegeme (3B), og

en første kontravægtventilspolefordybning (23), der er dannet på en ydre periferi af kontravægtventilspolelegemet (3B),
hvor, i en tilstand, hvor kontravægtventilspolen (3) er i den første kontravægtventilspoleposition, lukkes hovedventilspolens (2) udløbspassages (TP) indløb (TP1) af kontravægtventilspolen (3), og
i en tilstand, hvor kontravægtventilspolen (3) er i den anden kontravægtventilspoleposition, åbnes hovedventilspolens (2) udløbspassages (TP) indløb (TP1) af kontravægtventilspolen (3) gennem kontravægtventilspolens (3) første kontravægtventilspolefordybning (23), således at den anden arbejdsport (34) er i forbindelse med returporten (R) gennem indløbspassagen (17), der er konfigureret til den anden arbejdsport (34), den første kontravægtventilspolefordybning (23) og udløbspassagen (TP),
hvor, i en tilstand, hvor hovedventilspolen (2) er i den første hovedventilspoleposition, er den første arbejdsport (30) i forbindelse med den første tilførselsport (31), kontravægtventilspolen (3) er i den anden kontravægtventilspoleposition, og den anden arbejdsport (34) er i forbindelse med den anden returport (36) gennem indløbspassagen (17), der er konfigureret til den anden arbejdsport (34), den første kontravægtventilspolefordybning (23) og udløbspassagen (TP),
i en tilstand, hvor hovedventilspolen (2) er i den midterste hovedventilspoleposition, er kontravægtventilspolen (3) i den første kontravægtventilspoleposition, og den første arbejdsport (30) og den anden arbejdsport (34) er frakoblet fra henholdsvis den første tilførselsport (31) og den anden tilførselsport (33), og
i en tilstand, hvor hovedventilspolen (2) er i den anden hovedventilspoleposition, er kontravægtventilspolen (3) i den første kontravægtventilspoleposition, den første arbejdsport (30) er i forbindelse med den første returport (29), og den anden arbejdsport (34) er i forbindelse med den anden tilførselsport (33), og **kendetegnet ved, at** ventilhuset (1) endvidere omfatter et arbejdsporttrykdetektionshulrum (32), der er dannet i ventilhuslegemet (1B) og åbent mod hovedventilboringen (1C), og en første tilbageførselspassage og en anden tilbageførselspassage er dannet i hovedventilspolen (2), hvor:
når hovedventilspolen (2) er i den midterste hovedventilspoleposition, bringer hver af den første tilbageførselspassage og den anden tilbageførselspassage arbejdsporttrykdetektionshulrummet (32) i forbindelse med returporten (R),

når hovedventilspolen (2) er i den første hovedventilspoleposition, bringer den første tilbageførselspassage arbejdsporttrykdetektionshulrummet (32) i forbindelse med den første arbejdsport (30), og den anden tilbageførselspassage er frakoblet fra arbejdsporttrykdetektionshulrummet (32),

når hovedventilspolen (2) er i den anden hovedventilspoleposition, bringer den anden tilbageførselspassage arbejdsporttrykdetektionshulrummet (32) i forbindelse med den anden arbejdsport (34), og den første tilbageførselspassage er frakoblet fra arbejdsporttrykdetektionshulrummet (32).

2. Ventil ifølge krav 1, hvor:
udløbspassagen omfatter en flerhed af deludløbspassager, der er arrangeret i den aksiale retning, således at jo større en afstand, som kontravægtventilspolen glider i en retning fra den første kontravægtventilspoleposition mod den anden kontravægtventilspoleposition, er, jo flere deludløbspassager åbnes.

3. Ventil ifølge krav 1, hvor:
hovedventilspolens (2) hovedventilspoleindrehulrum (2C) omfatter: første og anden hovedventilspoleindrehulrum (2C1, 2C2), der strækker sig i den aksiale retning i hovedventilspolelegemet (2B), en hovedventilspoleindrehulrumsskillevæg (2P) mellem de første og anden hovedventilspoleindrehulrum (2C1, 2C2), et hovedventilspoleindrehulrumsskillevægsgennemgåendehul (9), der er dannet i hovedventilspoleindrehulrumsskillevæggen (2P) og bringer det første hovedventilspoleindrehulrum (2C1) i forbindelse med det andet hovedventilspoleindrehulrum (2C2), og et kontravægtventilfjederhulrum (20), der strækker sig fra det andet hovedventilspoleindrehulrum (2C2) i en retning væk fra det første hovedventilspoleindrehulrum (2C1),
kontravægtventilspolen (3) er anbragt i hovedventilspolens (2) andet hovedventilspoleindrehulrum (2C2) og har en første ende (3E1), der er tilstødende hovedventilspolens (2) hovedventilspoleindrehulrumsskillevæg (2P), og en anden ende (3E2), der er modstående den første ende (3E1),
idet ventilen (1) endvidere omfatter:
et kontravægtventilfjedersæde (4), der er anbragt i hovedventilspolens (2) kontravægtventilfjederhulrum (20) og har en ende (4E), der vender mod kontravægtventilspolen (3), og
en kontravægtventilfjeder (5, 6), der er anbragt i hovedventilspolens (2) kontravægtventilfjederhulrum (20) og konfigureret til at påføre en kraft på kontravægtventilfjedersædet (4) med henblik på at forspænde kontravægtventilfjedersædet (4) mod kontravægtventilspolen (3), således at

kontravægtventilfjedersædets (4) ende ligger an mod kontravægtventilspolens anden ende (3E2) og påfører en skubbekraft på kontravægtventilspolen (3) i en retning fra den anden kontravægtventilspoleposition mod den første kontravægtventilspoleposition.

4. Ventil ifølge krav 3, hvor:

kontravægtventilfjedersædet (4) omfatter: et hoved (4H), hvis ende vender mod kontravægtventilspolen (3), og en stang (4S), der er indført i kontravægtventilfjederen (5, 6), og

hovedventilspolen (2) endvidere omfatter en prop (7), der lukker en ende af hovedventilspolens (2) hovedventilspoleindrehulrum (2C), og som er konfigureret til at begrænse, ved et anlæg mod kontravægtventilfjedersædets (4) stang (4S), en afstand, som kontravægtventilfjedersædet (4) glider, og dermed en afstand, som kontravægtventilspolen (3) glider i en retning fra den første kontravægtventilspoleposition mod den anden kontravægtventilspoleposition.

5. Ventil ifølge krav 3, hvor:

den første tilbageførselspassage omfatter et første arbejdsporttrykoptagelseshul (21), der passerer gennem hovedventilspolens (2) hovedventilspolevæg (2W) i en retning, som krydser den aksiale retning, og som er åbent mod det første hovedventilspoleindrehulrum (2C1), i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den første hovedventilspoleposition, er det første arbejdsporttrykoptagelseshul (21) i forbindelse med den første arbejdsport (30), således at den første arbejdsport (30) er i forbindelse med hovedventilspolens (2) første hovedventilspoleindrehulrum (2C1) gennem det første arbejdsporttrykoptagelseshul (21).

6. Ventil ifølge krav 5, hvor:

den første tilbageførselspassage endvidere omfatter et første arbejdsporttryktilbageførselshul (26), der passerer gennem hovedventilspolens (2) hovedventilspolevæg (2W) i en retning, som krydser den aksiale retning, og som er åbent mod det første hovedventilspoleindrehulrum (2C1), i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen er i den første hovedventilspoleposition, er det første arbejdsporttryktilbageførselshul (26) i forbindelse med arbejdsporttrykdetektionshulrummet (32), således at arbejdsporttrykdetektionshulrummet (32) er i forbindelse med den første arbejdsport (30) gennem det første arbejdsporttryktilbageførselshul (26), det første hovedventilspoleindrehulrum (2C1) og det første

arbejdsporttrykoptagelseshul (21).

7. Ventil ifølge krav 5, hvor:
hovedventilspoleindrehulrumsskillevægsgennemgåendehullet (9) er et dæmpningshul, i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den første hovedventilspoleposition, er en åbningskraft, der påføres kontravægtventilspolen (3) gennem dæmpningshullet ved hjælp af et tryk i det første hovedventilspoleindrehulrum (2C1), større end en kraft, der påføres kontravægtventilspolen (3) ved hjælp af kontravægtventilfjederen(5, 6), således at kontravægtventilspolen (3) tvinges til at bevæge sig fra den første kontravægtventilspoleposition mod den anden kontravægtventilspoleposition.

8. Ventil ifølge krav 6, hvor:
i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den midterste hovedventilspoleposition, er det første arbejdsporttryktilbageførselshul (26) i forbindelse med arbejdsporttrykdetektionshulrummet (32), og det første arbejdsporttrykoptagelseshul (21) er i forbindelse med den første returport (R), således at arbejdsporttrykdetektionshulrummet (32) er i forbindelse med den første returport (R) gennem det første arbejdsporttryktilbageførselshul (26), det første hovedventilspoleindrehulrum (2C1) og det første arbejdsporttrykoptagelseshul (21),
i den tilstand, hvor hovedventilspolen (2) er i den anden hovedventilspoleposition, lukkes det første arbejdsporttryktilbageførselshul (26) af ventilhuslegemet (1B), således at det første arbejdsporttryktilbageførselshul (26) frakobles fra arbejdsporttrykdetektionshulrummet (32), og det første hovedventilspoleindrehulrum (2C1) er i forbindelse med den første returport (R) gennem det første arbejdsporttrykoptagelseshul (21).

9. Ventil ifølge krav 5, hvor:
den anden tilbageførselspassage omfatter et andet arbejdsporttrykoptagelseshul (8), der passerer gennem hovedventilspolens (2) hovedventilspolevæg (2W) i en retning, som krydser den aksiale retning, og som er åbent mod kontravægtventilfjederhulrummet (20), der er et mellemrum mellem kontravægtventilspolen (3) og en indvendig væg af hovedventilspolens (2) kontravægtventilfjederhulrum (20), og når kontravægtventilspolen (3) er i hver af den første kontravægtventilspoleposition og den anden kontravægtventilspoleposition, er kontravægtventilfjederhulrummet (20) i forbindelse med det andet

arbejdsporttrykoptagelseshul (8) gennem mellemrummet.

10. Ventil ifølge krav 9, hvor:
en kontravægtventilfjedersædefordybning (25) er dannet ved en endeoverflade af kontravægtventilfjedersædets (4) ende på en ydre periferi af kontravægtventilfjedersædets ende, og kontravægtventilfjedersædefordybningen (25) er i forbindelse med mellemrummet med henblik på at udgøre en del af kontravægtventilfjederhulrummet (20).

11. Ventil ifølge krav 9 eller 10, hvor:
den anden tilbageførselspassage endvidere omfatter et andet arbejdsporttryktilbageførselshul (27), der passerer gennem hovedventilspolens (2) hovedventilspolevæg (2W) i en retning, som krydser den aksiale retning,
den anden tilbageførselspassage endvidere omfatter: et kontravægtventilspoleforbindelseshul (15C), der er dannet i kontravægtventilspolelegemet (3) i en retning, som krydser den aksiale retning, og et kontravægtventilspoleaksialhul (15), der er dannet i kontravægtventilspolelegemet (3B) i det væsentlige i aksial retning, og som er i forbindelse med kontravægtventilspoleforbindelseshullet (15C),
den anden tilbageførselspassage endvidere omfatter en kontravægtventilfjedersæderille (16), der er dannet ved en endeoverflade af kontravægtventilfjedersædets (4) ende, og som strækker sig i en retning, der krydser den aksiale retning, idet kontravægtventilfjedersæderillen (16) er i forbindelse med både kontravægtventilspoleaksialhullet (15) og kontravægtventilfjederhulrummet (20).

12. Ventil ifølge krav 11, hvor:
i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (16) er i den midterste hovedventilspoleposition, er kontravægtventilspolen (3) i den første kontravægtventilspoleposition, det andet arbejdsporttryktilbageførselshul (27) er i forbindelse med både arbejdsporttrykdetektionshulrummet (32) og kontravægtventilspoleforbindelseshullet (15C), og det andet arbejdsporttrykoptagelseshul (8) er i forbindelse med den anden returport (36), således at arbejdsporttrykdetektionshulrummet (32) er i forbindelse med den anden returport (36) gennem det andet arbejdsporttryktilbageførselshul (27), kontravægtventilspoleforbindelseshullet (15C), kontravægtventilspoleaksialhullet (15), kontravægtventilfjedersæderillen (16), kontravægtventilfjederhulrummet (20) og det andet arbejdsporttrykoptagelseshul (8),

kontravægtventilspolen (3) fortrinsvis endvidere omfatter: en anden kontravægtventilspolefordybning (22), der er dannet på den ydre periferi af kontravægtventilspolelegemet (3B), kontravægtventilspoleforbindelseshullet (15C) bringer den anden kontravægtventilspolefordybning (22) i forbindelse med kontravægtventilspoleaksialhullet (15), og i den tilstand, hvor hovedventilspolen i hovedventilboringen er i den midterste hovedventilspoleposition, er det andet arbejdsporttryktilbageførselshul (27) i forbindelse med kontravægtventilspoleforbindelseshullet (15C) gennem den anden kontravægtventilspolefordybning (22).

13. Ventil ifølge krav 11, hvor:

i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den første hovedventilspoleposition, er kontravægtventilspolen (3) i den anden kontravægtventilspoleposition, således at kontravægtventilspolens (3) anden ende (3E2) trænger ind i kontravægtventilfjederhulrummet (20), kontravægtventilfjederhulrummet (20) er i forbindelse med den anden returport (36) gennem et mellemrum mellem kontravægtventilfjedersædet (4) og hovedventilspolens (2) kontravægtventilfjederhulrums (22) indvendige væg, mellemrummet mellem kontravægtventilspolen (3) og hovedventilspolens (2) kontravægtventilfjederhulrums (20) indvendige væg, og det anden arbejdsporttrykoptagelseshul (8), og

i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den første hovedventilspoleposition, lukkes det andet arbejdsporttryktilbageførselshul (27) af ventilhuslegemet (1B), således at det andet arbejdsporttryktilbageførselshul (27) frakobles fra arbejdsporttrykdetektionshulrummet (32).

14. Ventil ifølge krav 11, hvor:

i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den anden hovedventilspoleposition, er det andet arbejdsporttryktilbageførselshul (27) i forbindelse med både arbejdsporttrykdetektionshulrummet (32) og kontravægtventilspoleforbindelseshullet (15C), og det andet arbejdsporttrykoptagelseshul (8) er i forbindelse med den anden arbejdsport (34), således at arbejdsporttrykdetektionshulrummet (32) er i forbindelse med den anden arbejdsport (34) gennem det andet arbejdsporttryktilbageførselshul (27), kontravægtventilspoleforbindelseshullet (15C), kontravægtventilspoleaksialhullet (15), kontravægtventilfjedersæderillen (16), kontravægtventilfjederhulrummet (20) og det andet arbejdsporttrykoptagelseshul (8),

kontravægtventilspolen (3) fortrinsvis endvidere omfatter: en anden kontravægtventilspolefordybning (22), der er dannet på den ydre periferi af kontravægtventilspolelegemet (3B), kontravægtventilspoleforbindelseshullet (15C) bringer den anden kontravægtventilspolefordybning (22) i forbindelse med kontravægtventilspoleaksialhullet (15), og i den tilstand, hvor hovedventilspolen (2) i hovedventilboringen (1C) er i den anden hovedventilspoleposition, er det andet arbejdsporttryktilbageførselshul (27) i forbindelse med kontravægtventilspoleforbindelseshullet (15C) gennem den anden kontravægtventilspolefordybning (22).

15. Hydraulisk system (200), der omfatter:
ventilen (10) ifølge krav 1.

DRAWINGS

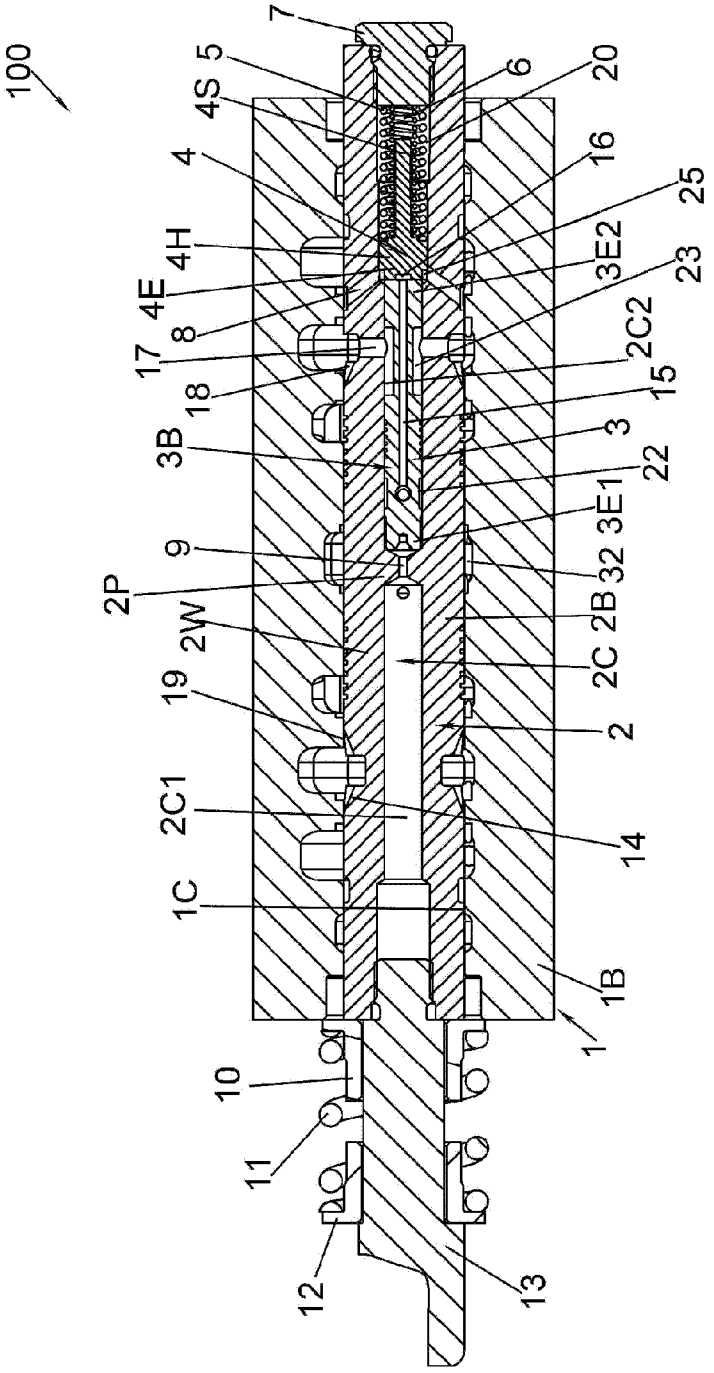

Fig. 1

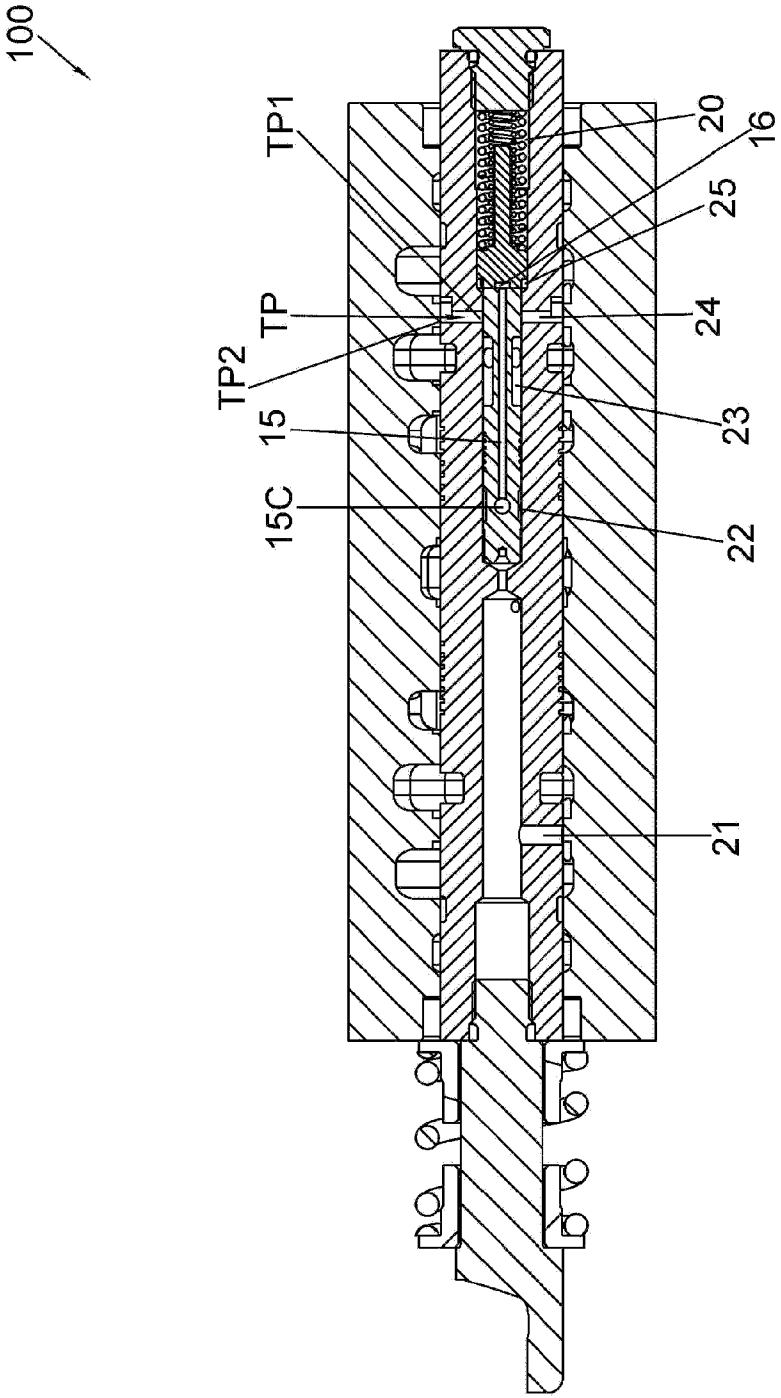

Fig. 2

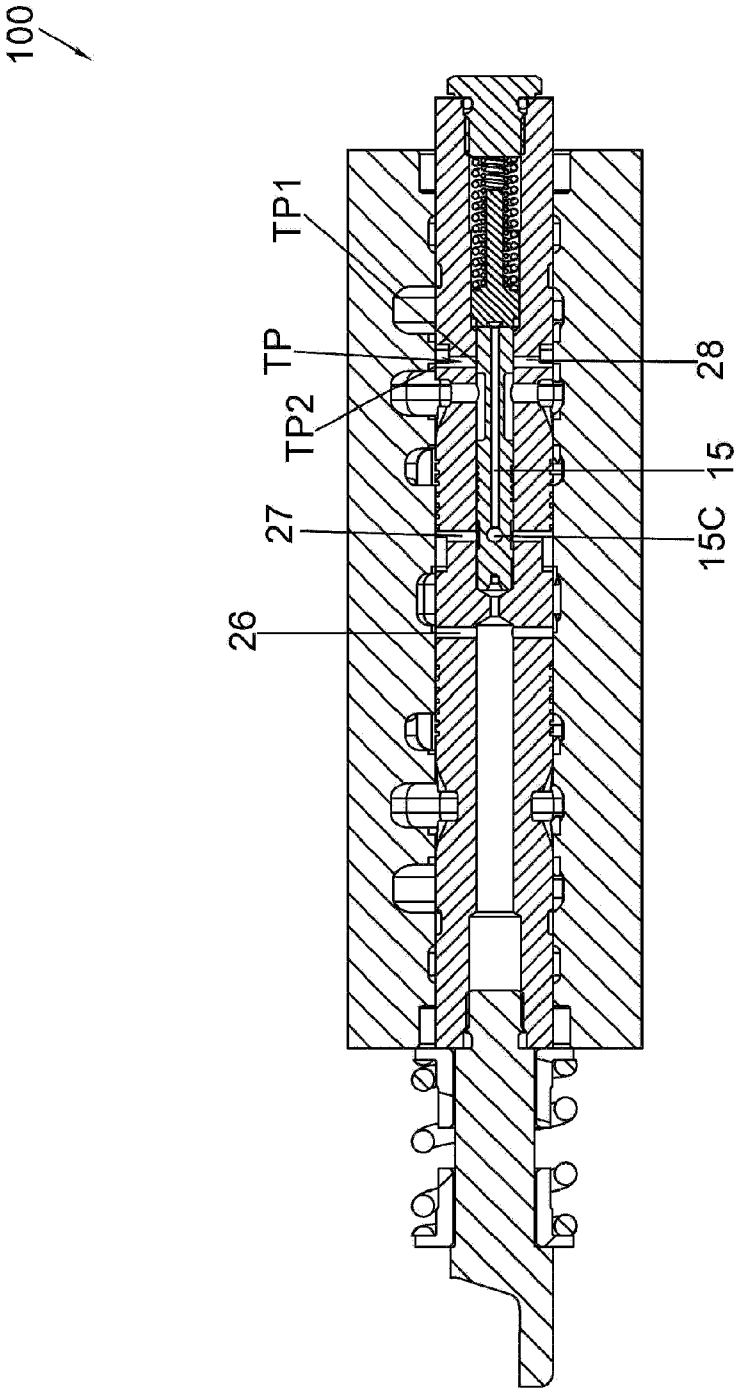

Fig. 3

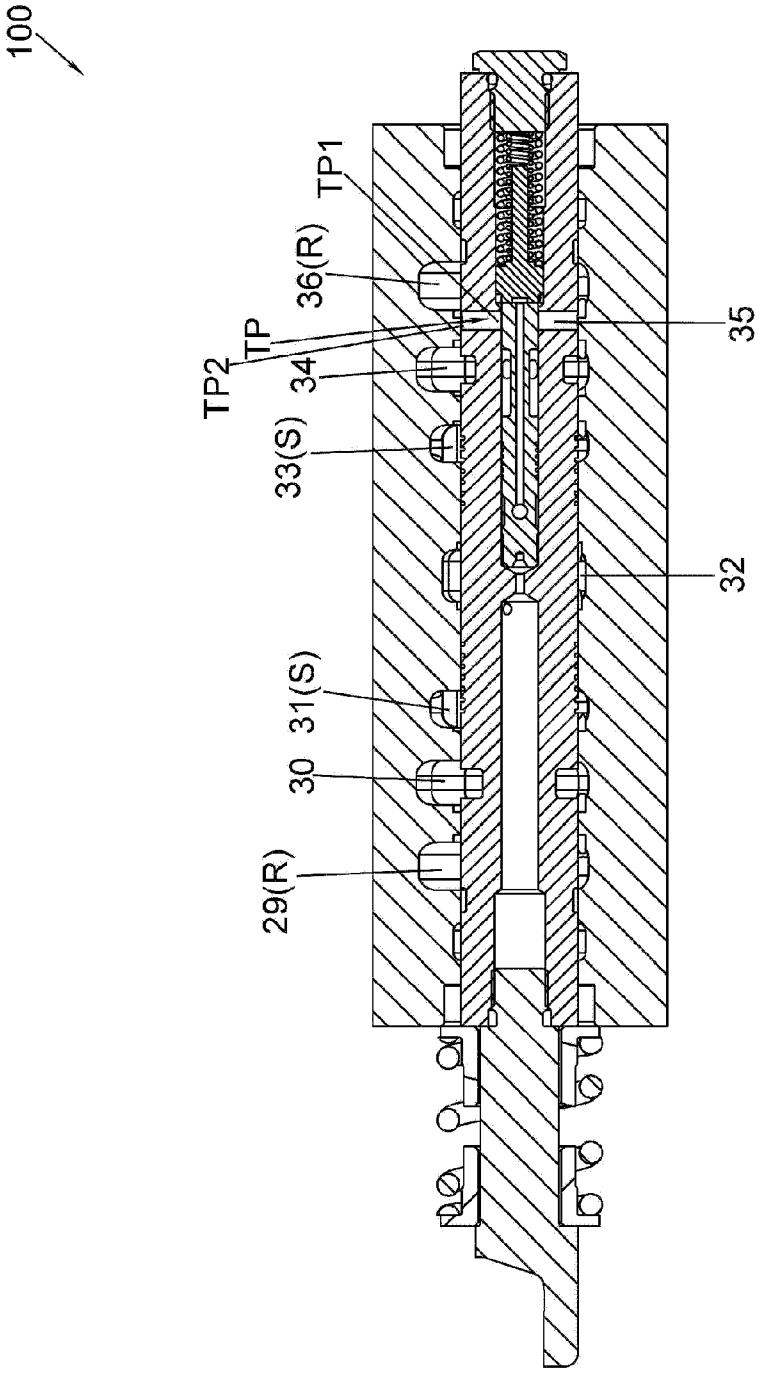

Fig. 4

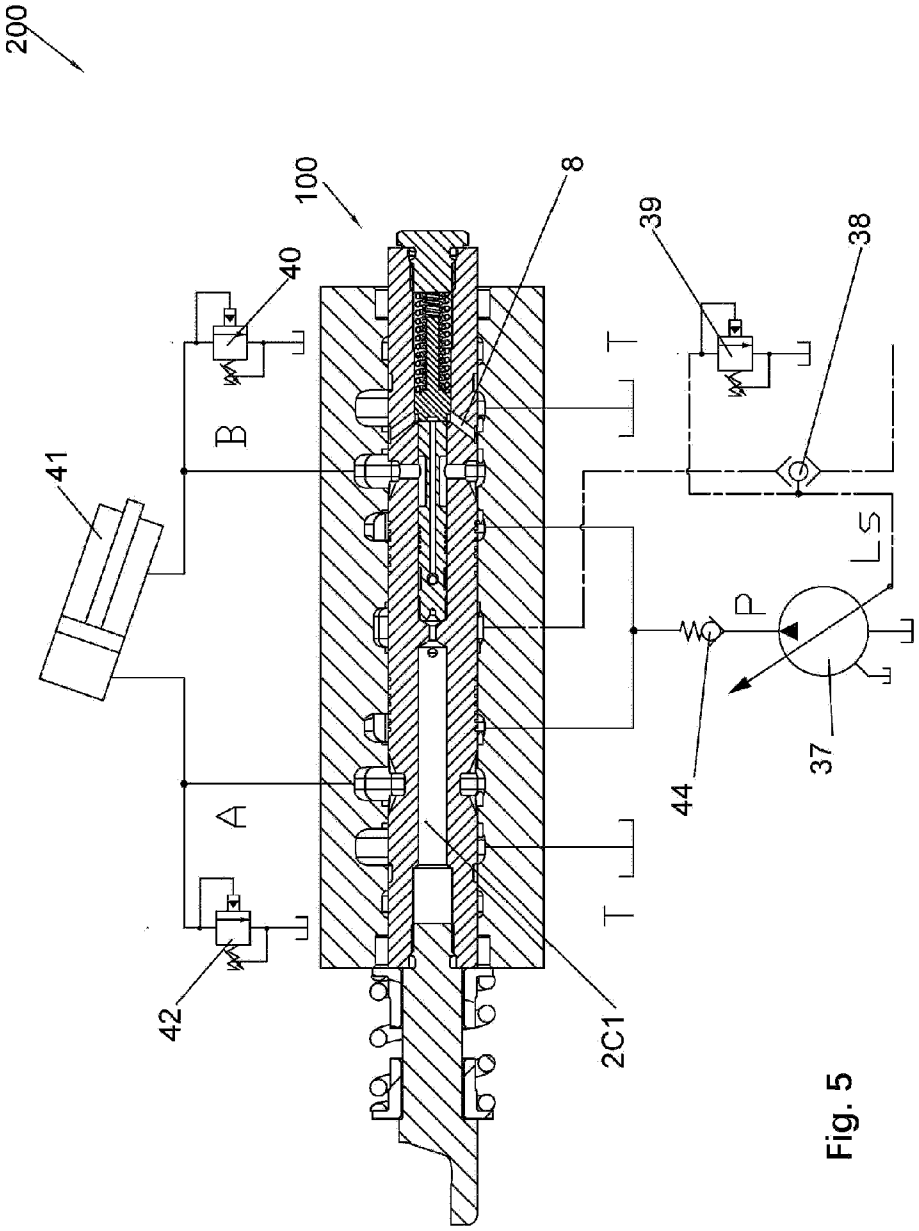

Fig. 5

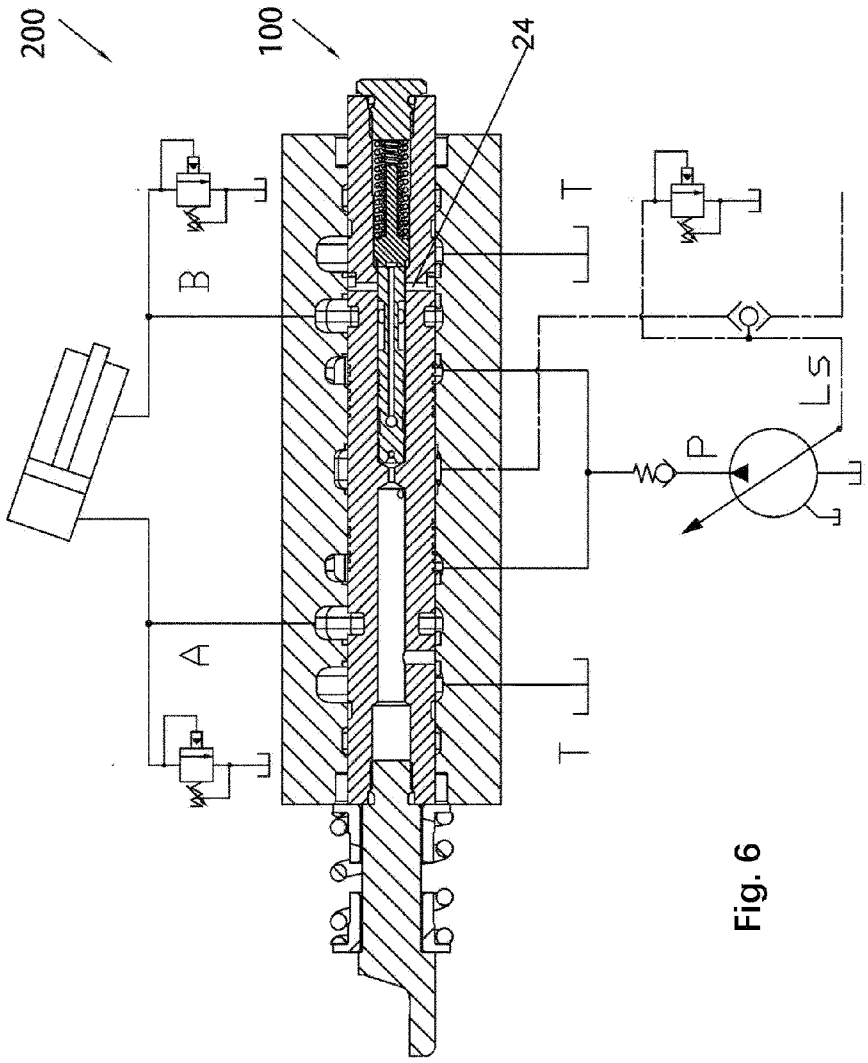

Fig. 6

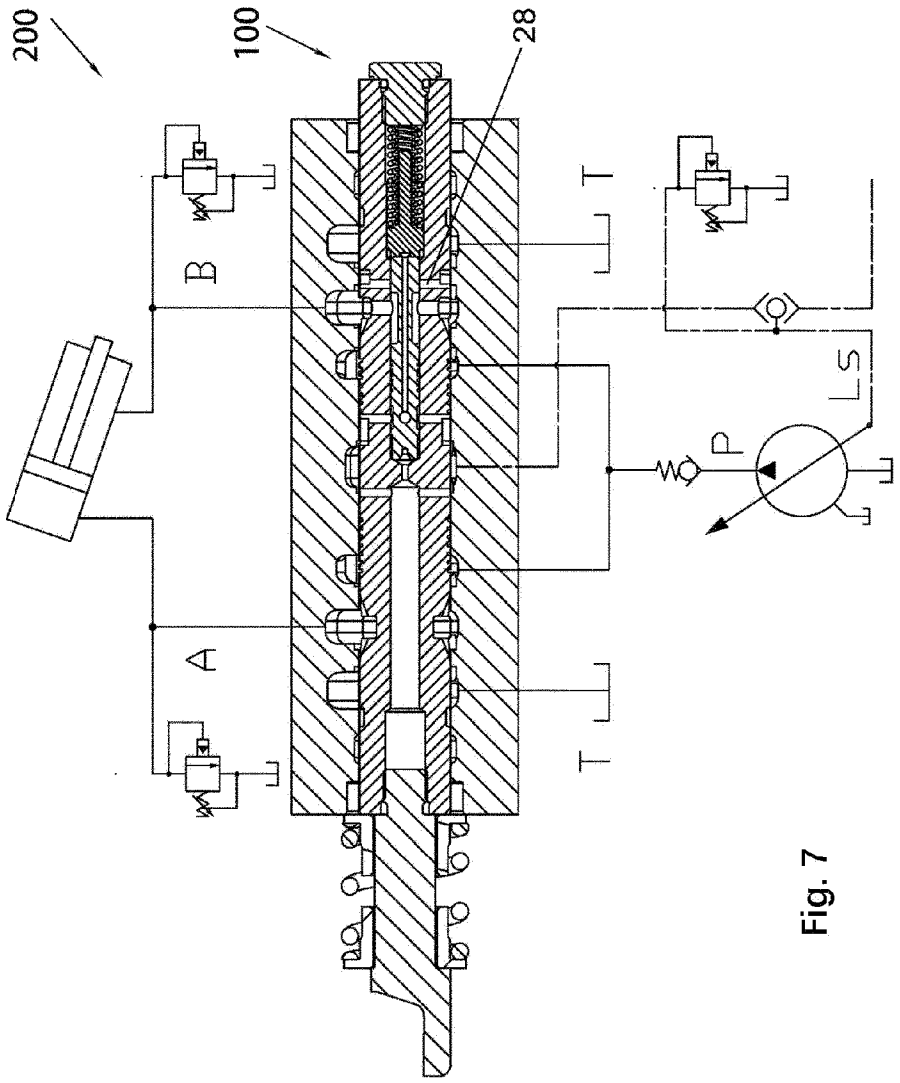

Fig. 7

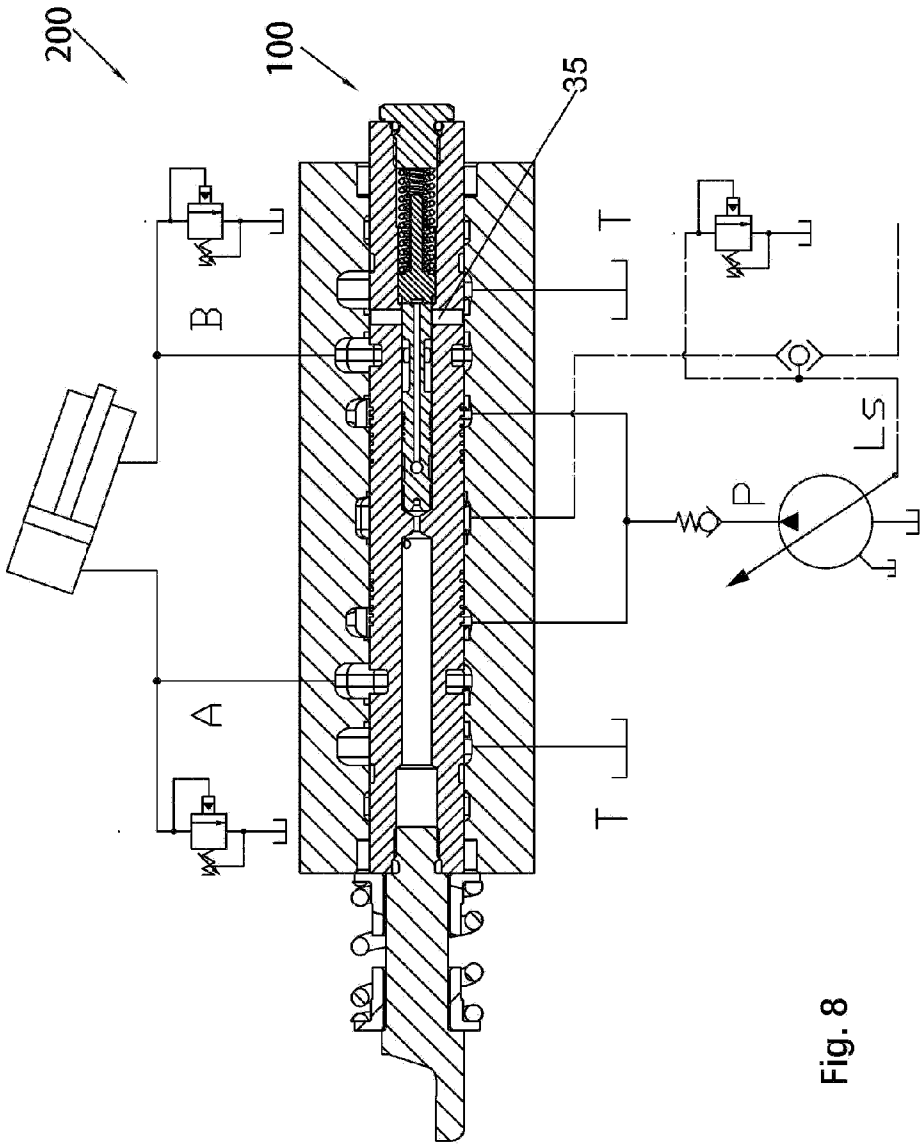

Fig. 8

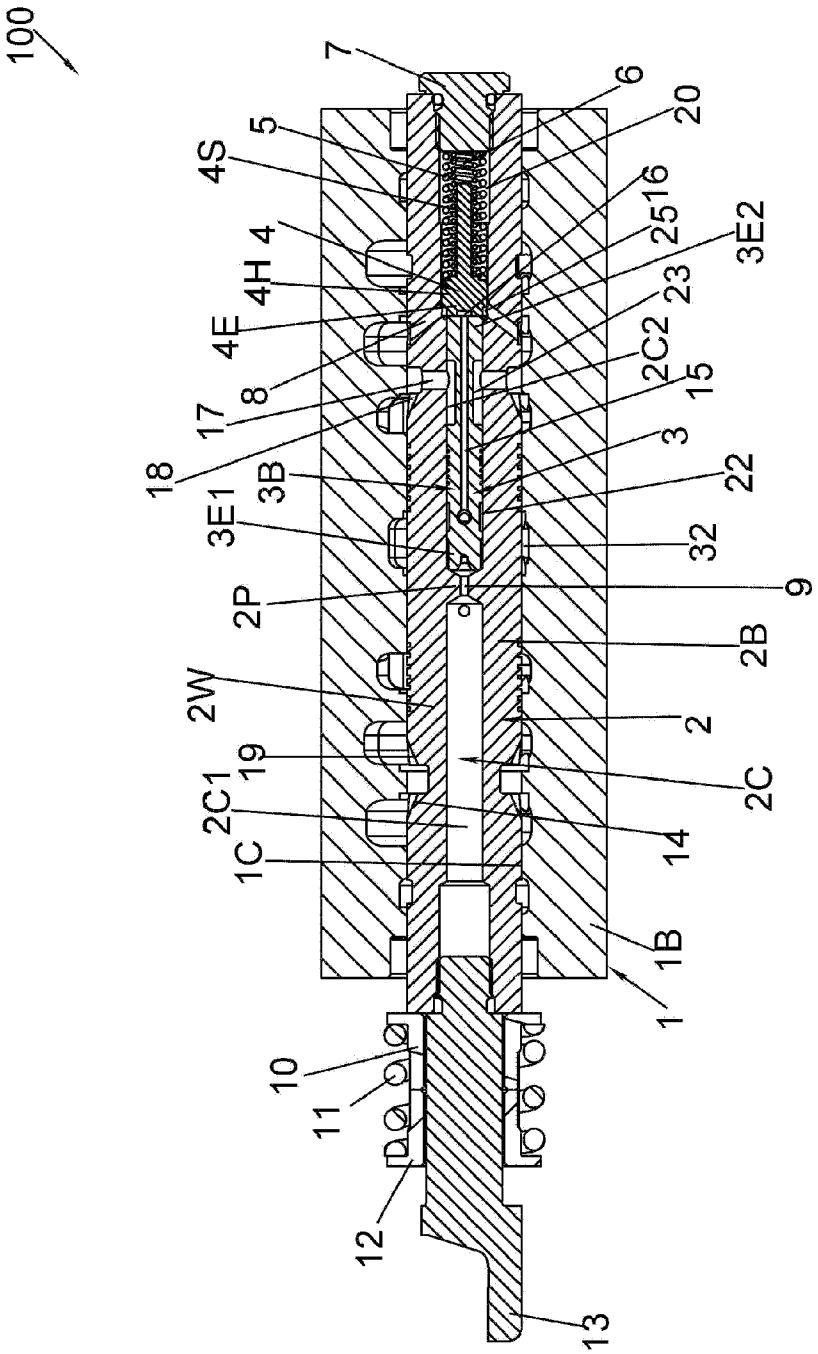
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Fig. 9

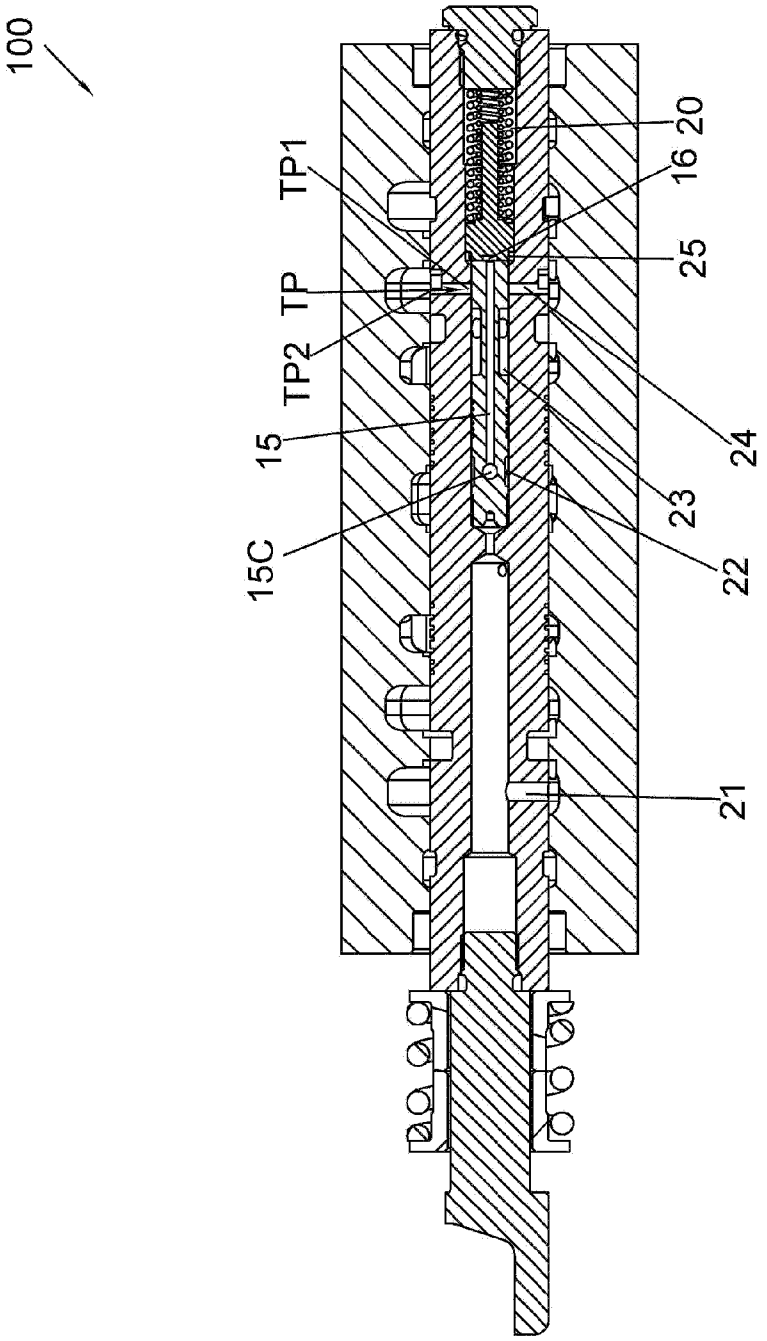

Fig. 10

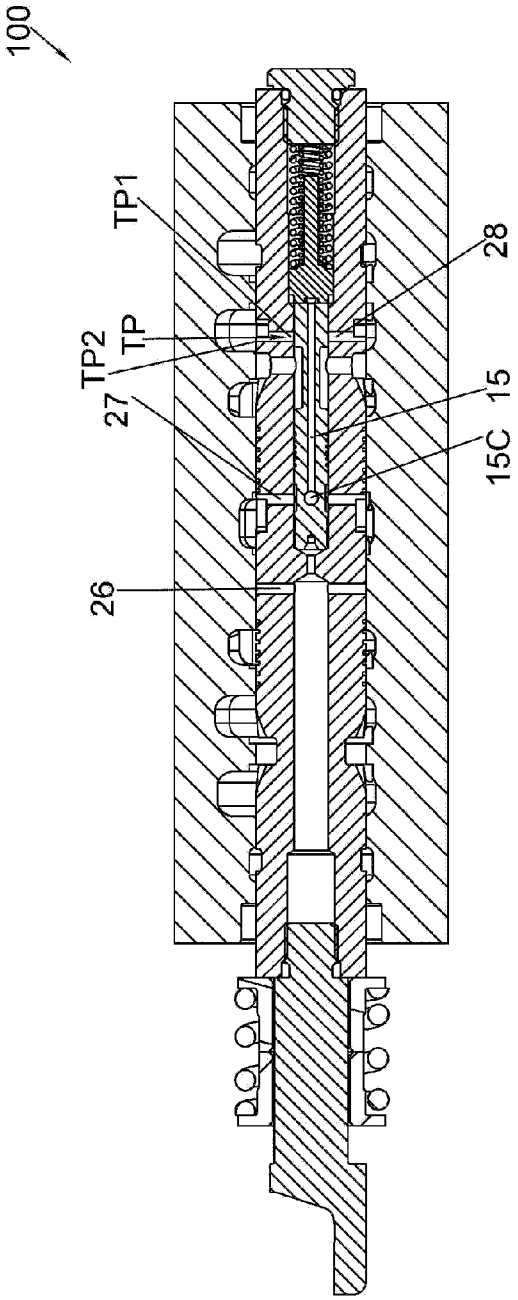

Fig. 11

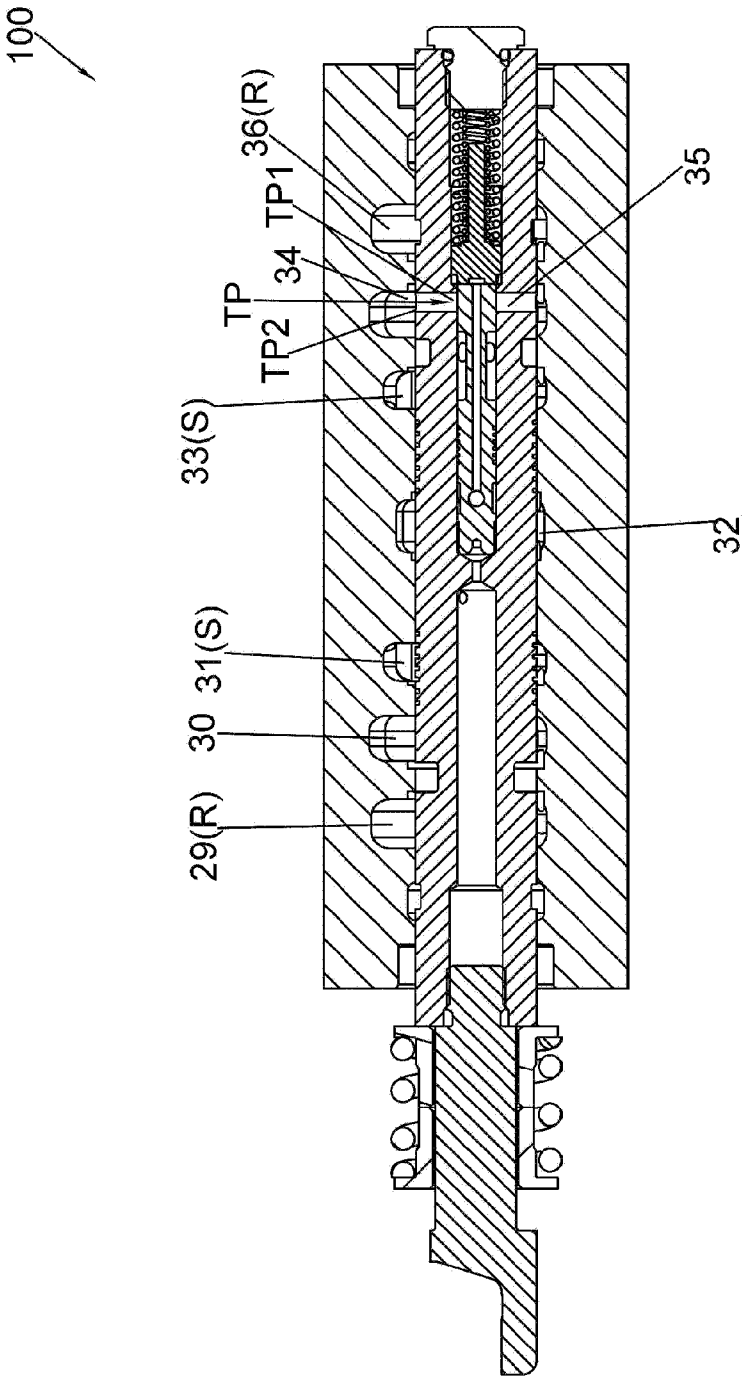

Fig. 12

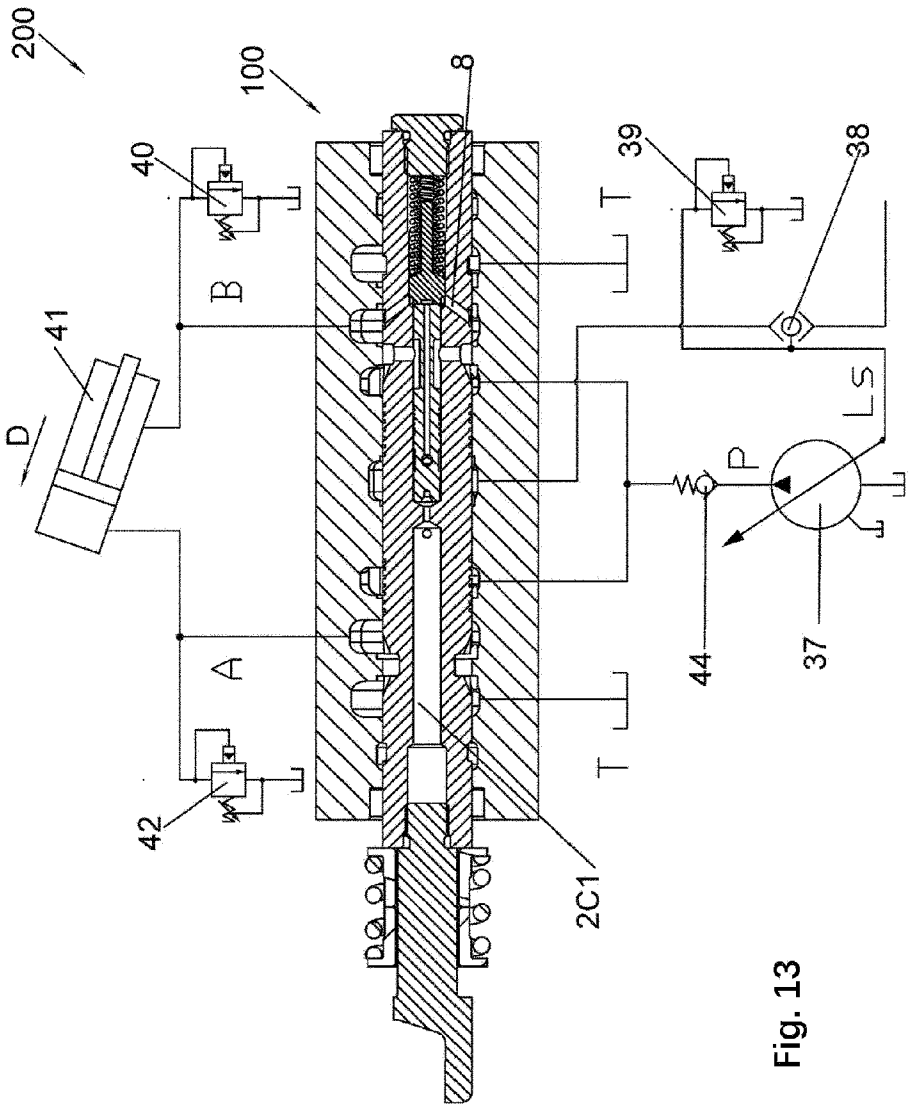

Fig. 13

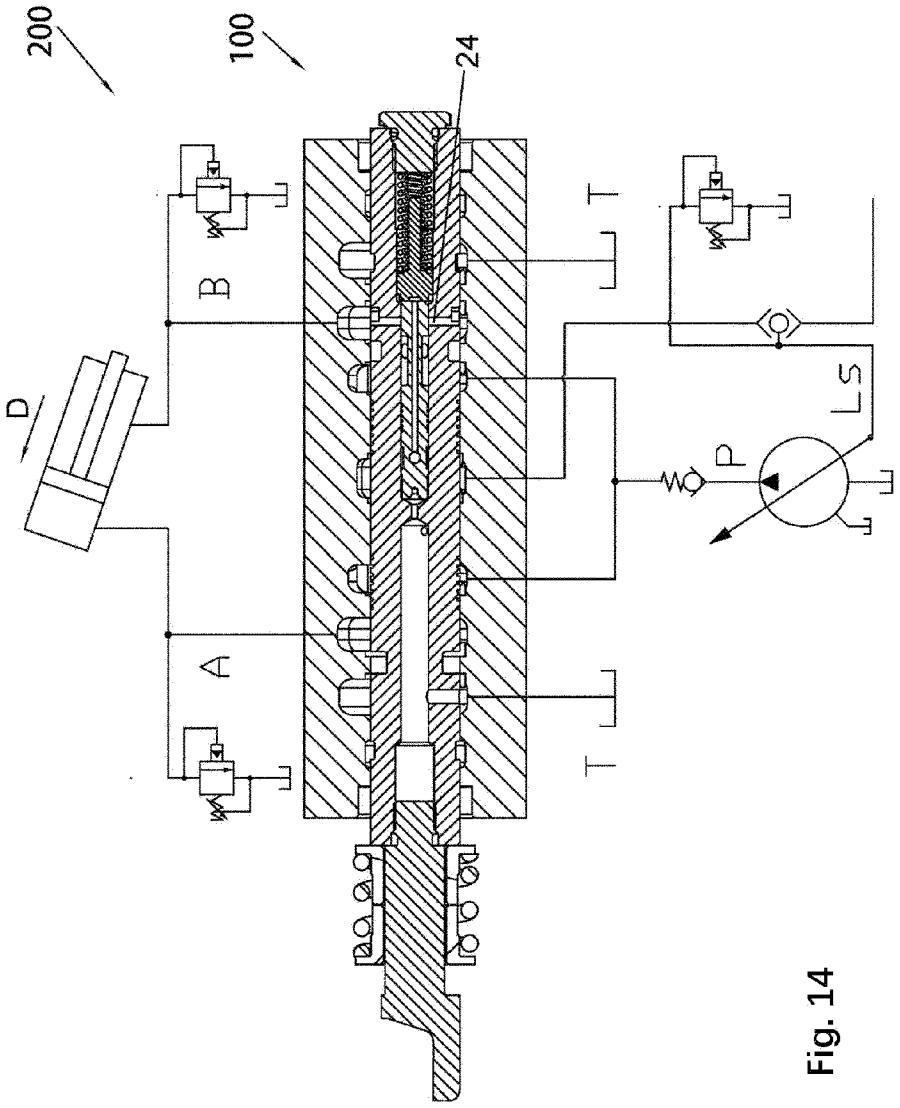

Fig. 14

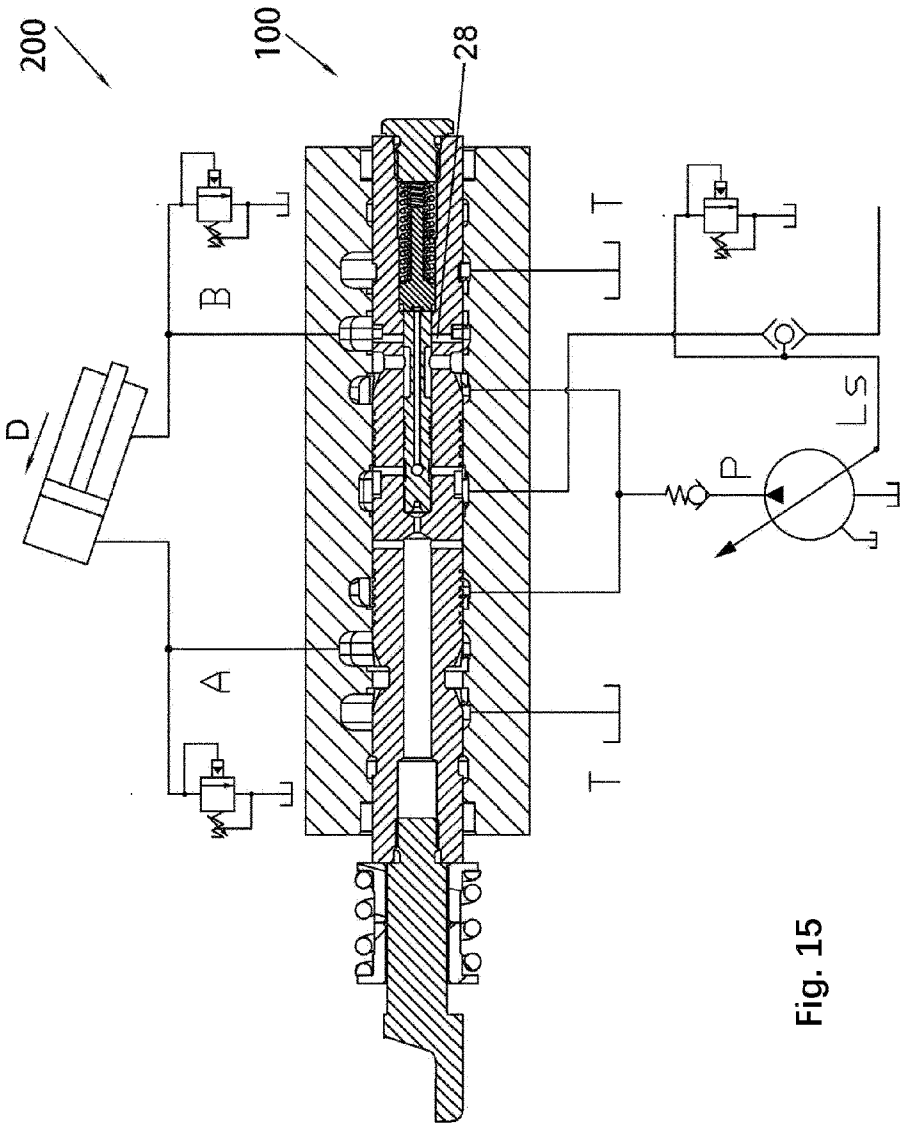

Fig. 15

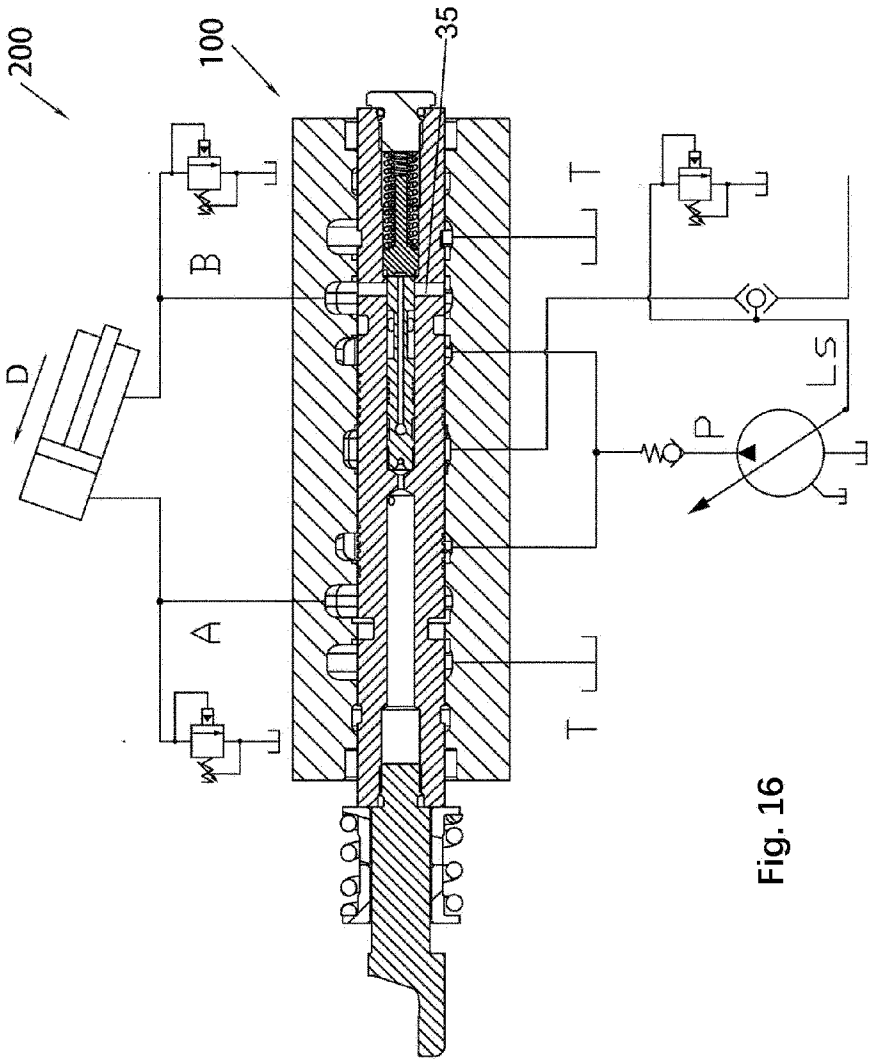

Fig. 16

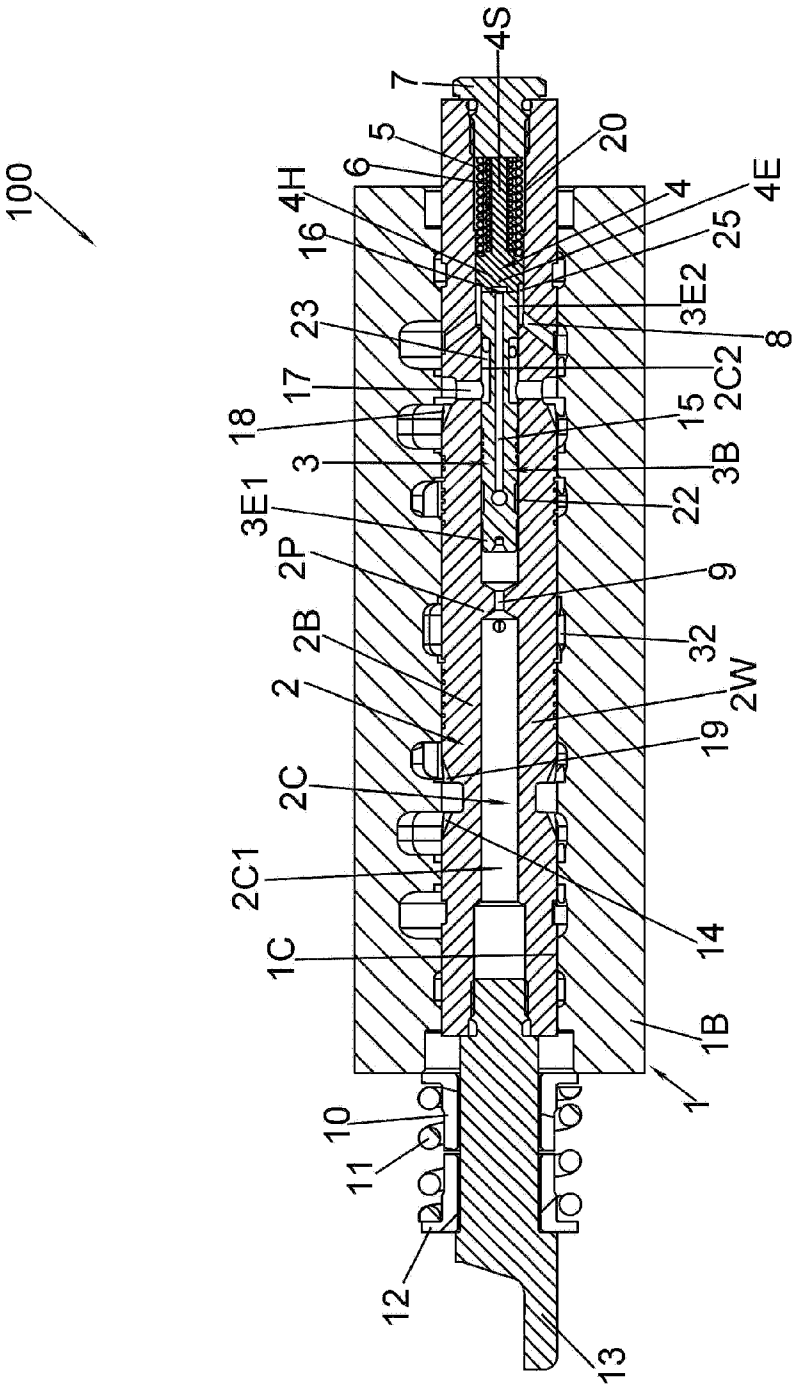
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Fig. 17

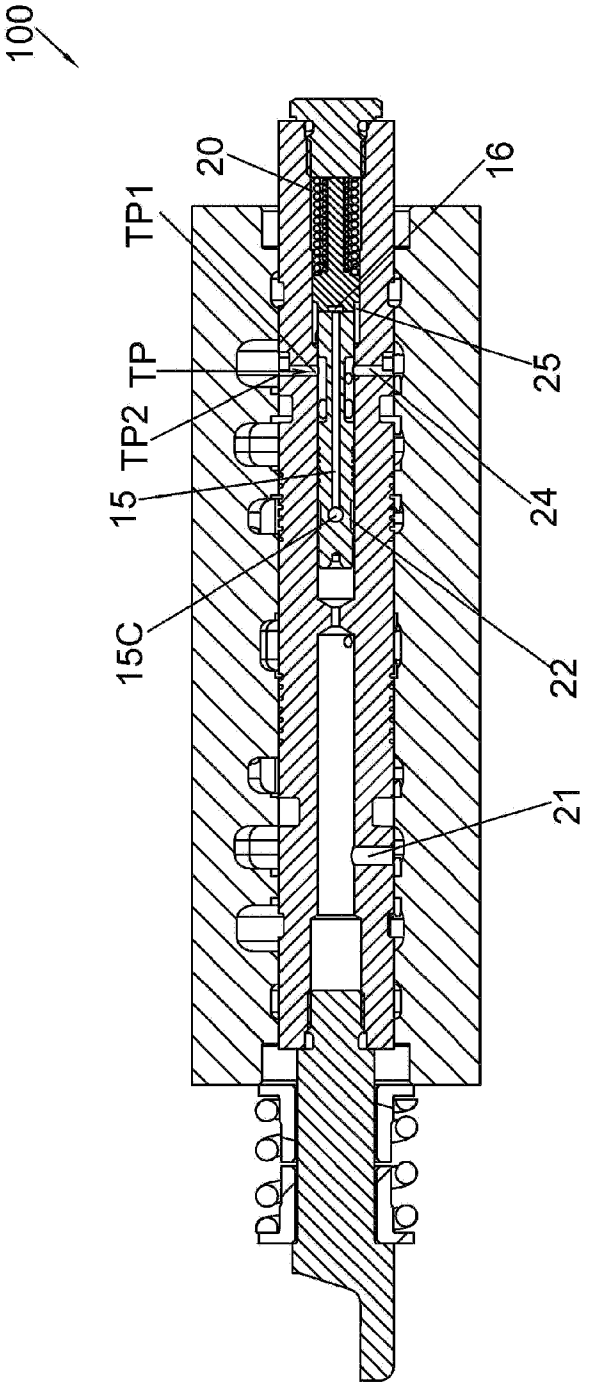

Fig. 18

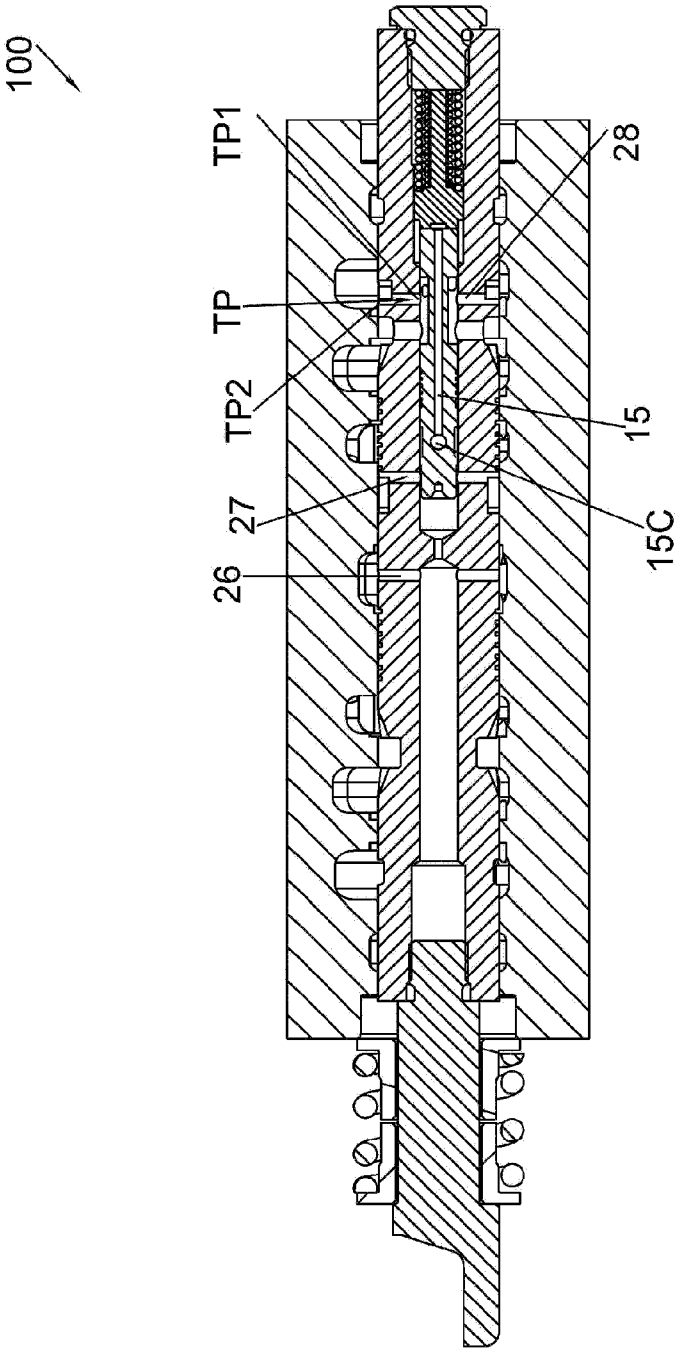

Fig. 19

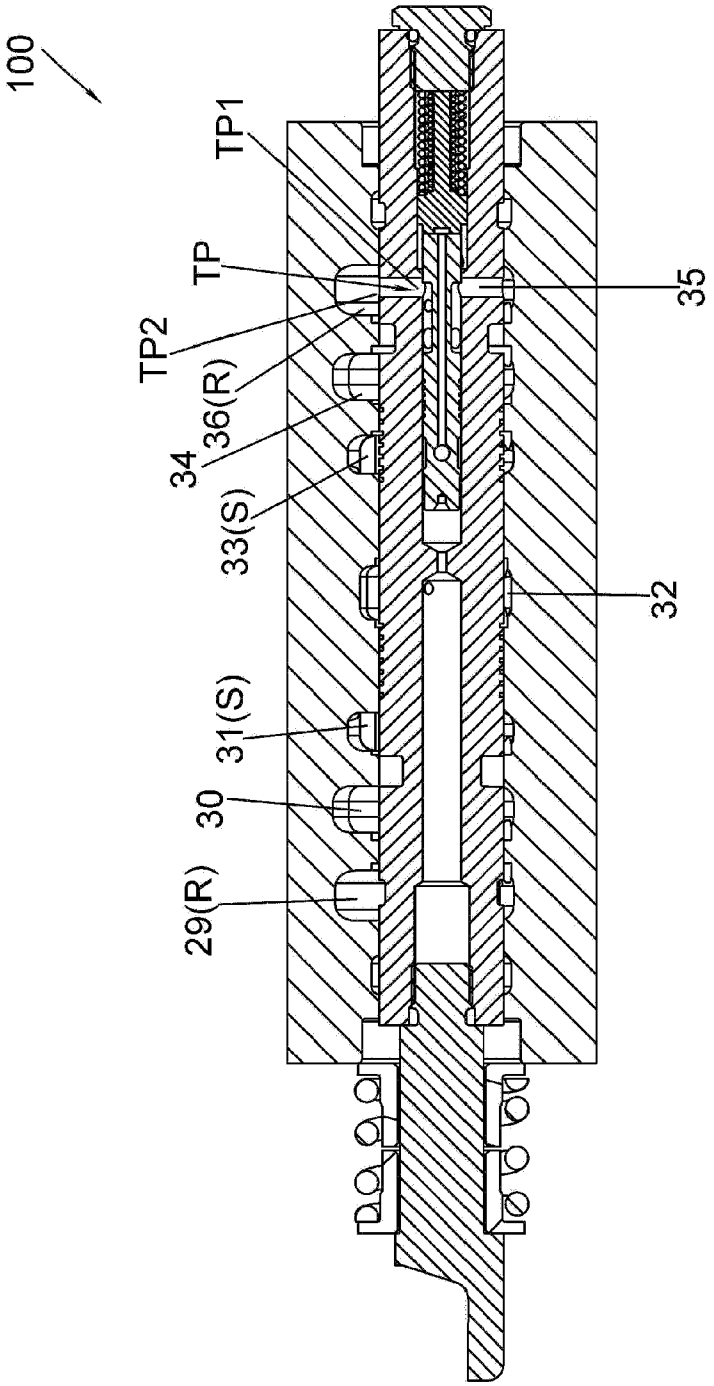

Fig. 20

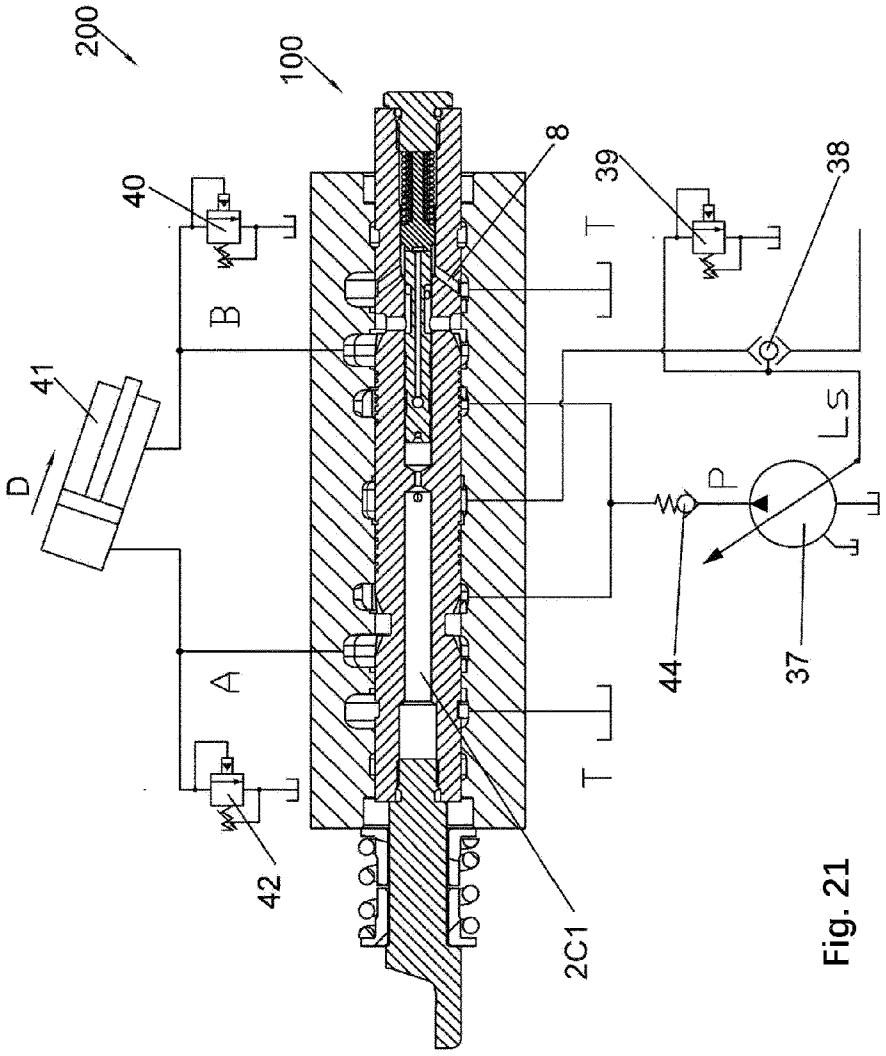

Fig. 21

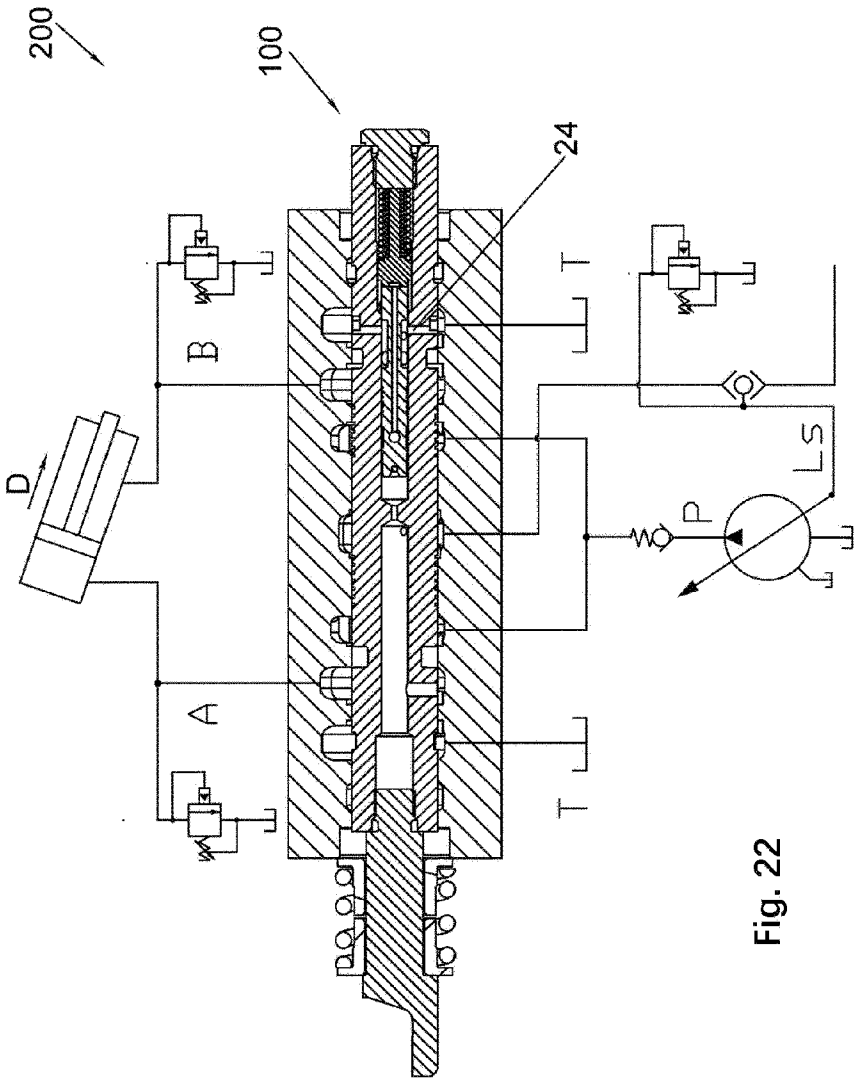

Fig. 22

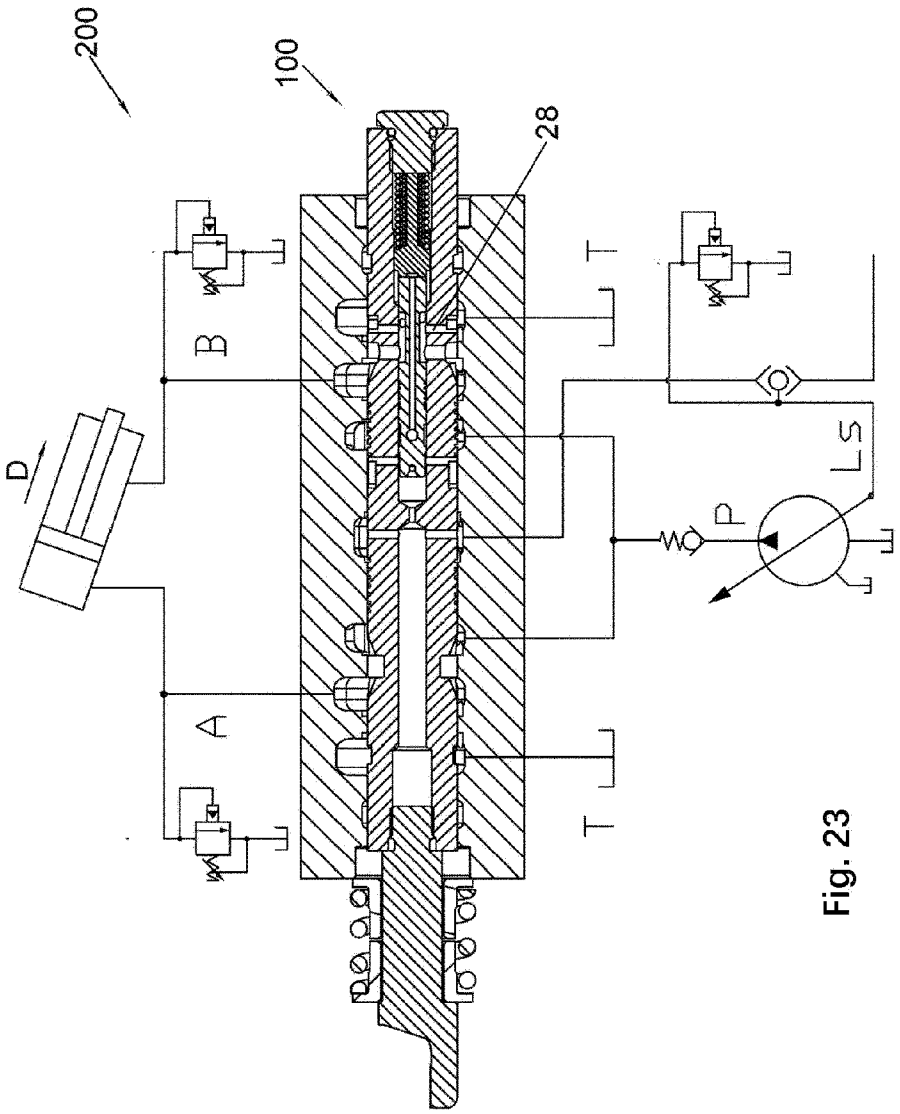

Fig. 23

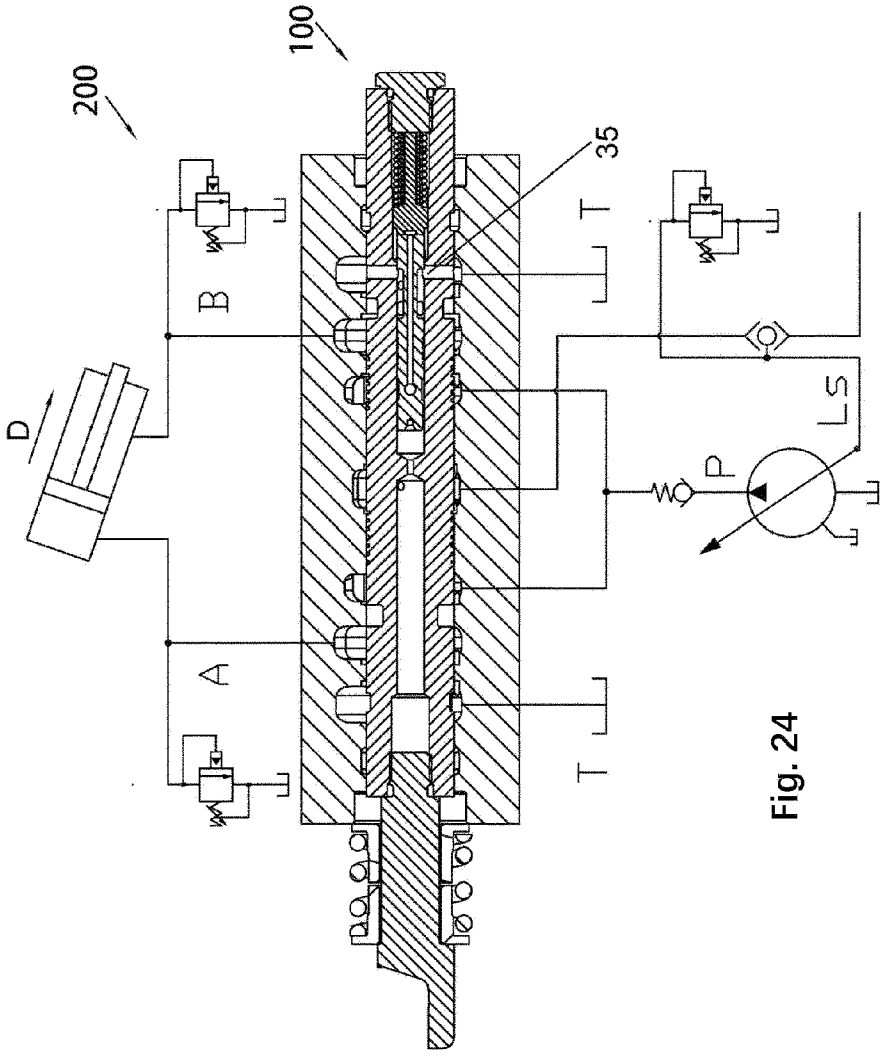

Fig. 24