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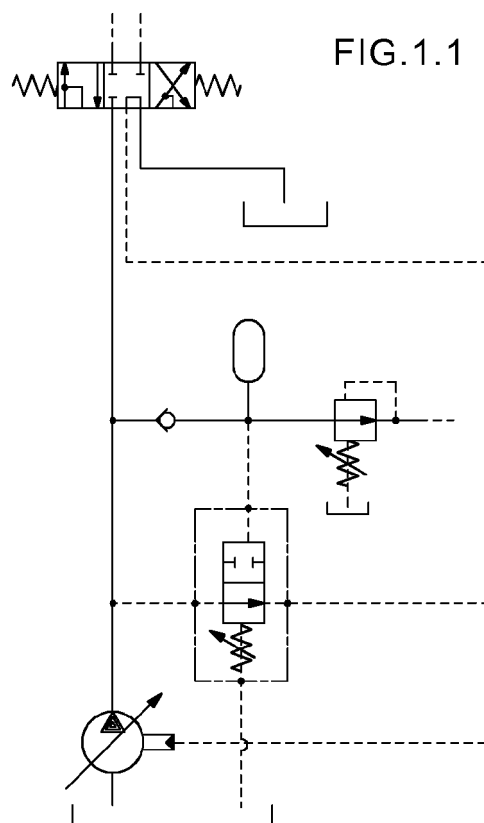
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(54) **Differential sequence hydraulic valve**

(57) An outer pilot double adjustment differential directional four-way slide (5) valve (20) normally opened or normally closed, of the type comprising: a piloting port (1), inlet and outlet flow rate ports (2, 3), a drainage port (4), connected to a drain. During the increasing pressure step at the piloting port (2), when it is reached the increasing adjustment value, the valve operates by opening (if it is normally closed), or closing (if it is normally opened) the passage between the ports (2) and (3) dedicated to the oil passage. During the pressure reduction step at the piloting port (1), when it is reached the decreasing adjustment value, the valve returns to the starting arrangement. Both in the rest position and the stop position, the piloting port (1) and the ports (2) and (3) are isolated from the drainage port (4).



Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of the differential sequence hydraulic valves having a double adjustment which manage the opening and closure of an oil passage between two ports of the valve, based on an outer pressure signal acting on the piloting port of the valve itself.

[0002] As said, generally the sequence valves are used in systems in which the event order is determined by the pressure in the circuit itself.

[0003] A possible application is in the load sensing hydraulic circuits dedicated to the management of a differential load of an accumulator.

[0004] A second possible application refers to the low flow rate hydraulic systems supplied by an accumulator loaded by a fixed-displacement pump. The valve, in such circuit, has the function of discharging the flow rate of the same pump when the accumulator is loaded.

[0005] A third possible application refers to the low flow rate hydraulic systems having a fixed-displacement dedicated to the management of a differential load of an accumulator.

[0006] The valve in object, suitably inserted in such types of circuits, enables to increase the hydraulic circuit pressure in order to load an accumulator to a pressure value predetermined by the increasing adjustment of the valve itself.

[0007] When the accumulator pressure decreases below a specific pressure value, equals to the decreasing adjustment pressure of the valve, the valve itself operates by determining again the accumulator load.

[0008] Therefore, the part of the circuit supplied by the accumulator works between two pressure levels determined by a differential typical of the valve in object.

STATE OF THE ART

[0009] There are known different types of sequence valves characterized by different double increasing and decreasing adjustment pressures, whose detailed description will be given in the following. Particularly, there are four-way pilot outer drainage valves, characterized by a main stage which, in the rest position, closes the oil passage between the ports and by a double adjustment pilot stage.

[0010] Disadvantageously, in order to keep switched this type of valve, it is necessary to have a continuous flow of oil from the inlet port to the drainage port: this fact determines a flow rate loss and consequently a waste of power.

[0011] There is a second type of valve characterized by a double adjustment pressure.

[0012] It is an outer piloting three-way valve substantially comprising a pilot stage of the above mentioned valve. Such valve must be coupled to a logic element,

which determines the closure and opening of the passage for the oil delivered by the pump.

[0013] Also in this approach, it is always necessary to drain the discharge oil through the cited valve in order to keep opened the logic element.

[0014] Both the described valves have been designed to work in systems requiring high working flow rate, but they are not adapted to work in load sensing circuits, both with a LS pump, and with a pressure compensator. The sizes of the oil passages in the above described systems are not adapted to manage a flow rate signal as required in this type of system. In fact, the piloted systems are instable with low work flow rates and a response time longer than the one of a direct operation approach.

DISCLOSURE OF THE INVENTION

[0015] It is an object of the present invention to solve the above mentioned disadvantages and all the disadvantages of the prior art, by providing a double adjustment differential sequence valve which does not have an oil drainage to the discharge when it is switched.

[0016] Another object of the present invention is to provide a differential sequence double adjustment valve having a compact arrangement and reduced exchanging times.

[0017] More specifically, it is a direct slide, four-way, double adjustment, differential valve having an outer pilot, usually opened or usually closed.

[0018] Operatively, in the pilot pressure increasing step, once it has been reached the adjustment increasing value, the valve operates by opening (if it is normally closed) or closing (if it is normally opened) the passage between the two ways dedicated to the oil flow.

[0019] In the pilot pressure decreasing step, once it has been reached the decreasing adjustment value, the valve goes back to the starting arrangement.

[0020] The increasing adjustment pressure value is always greater than the one of the decreasing adjustment pressure and the ratio between the two values is determined by the differential valve.

ADVANTAGES:

[0021]

- The main advantage of the present invention is due to the fact the valve keeps the switched position thanks to the pressure signal present at the port 1: therefore it is not necessary to drain the oil flow rate through the drainage port.
- The second advantage is due to the fact that is a slide valve, so it is not required the presence of a sealing element piloting the main stage of the valve: the slide of the valve in fact operates both as a pilot stage and as a main stage. Anyway, the valve can manage a flow rate passing between the two ports which is greater than the one of an oil signal.

- A further advantage is due to the fact that the valve has a direct operation: this enables an switching dynamics which is more controllable than the one of a piloted operation valve. Particularly, it is possible to have lower exchange times with a greater dynamic stability of the pressures of the system.
- At last, the presence of throttles on the slide enables to act on the operating times, in order to further increase the stability of the circuit in which is inserted.

[0022] Said objects and advantages are all met by the differential sequence hydraulic valve, object of the present invention, which is characterized by the attached claims.

BRIEF DESCRIPTION OF THE FIGURES

[0023] This and other features will be better understood by the following description of some embodiments shown as an illustrative and non limiting example in the attached drawings.

- Figures 1.1, 1.2, 1.3: show the hydraulic diagrams of three application examples of the valve, in which the same has been shown schematically,
- Figures 2.1, 2.2: show the hydraulic diagrams of two application examples of the valves according to the prior art,
- Figures 3.1, 3.2, 3.3: show the hydraulic symbols of the invention and an example of application,
- Figures 4.1, 4.2: show the hydraulic symbols and the cross-sections of the two types of valves of the prior art,
- Figure 5.1: shows the implementation of the invention with different highlighted details which make up the valve,
- Figures 5.2 - 5.5: show the valve in the different positions which it takes during the switching.

DESCRIPTION OF THE FIELD OF THE INVENTION

[0024] With reference to Figure 1.1, it is shown a first application of the valve of the invention.

[0025] It is a load sensing hydraulic system dedicated to the management of a differential load of an accumulator. In such circuit, the valve is branched with respect to the main line supplied by the pump.

[0026] With reference to Figure 1.2, it is shown a second application of the valve of the invention.

[0027] It is a low flow rate hydraulic system supplied by an accumulator loaded by a fixed-displacement pump. The valve in such circuit is branched with respect to the main line supplied by the pump and it discharges the flow rate of the same pump, when the accumulator is loaded.

[0028] With reference to Figure 1.3, it is shown a third application of the valve of the invention.

[0029] It is a low flow rate hydraulic system having a fixed-displacement pump dedicated to the management

of a differential load of an accumulator. In such circuit, the valve is in series to the pump.

DESCRIPTION OF THE PRIOR ART

[0030] Particularly, with reference to Figures 2.1, 2.2, hydraulic diagrams of two examples using the valves according to the prior art are shown.

[0031] The first example of the prior art is shown in Figure 2.1.

[0032] The hydraulic diagram of an example of application of the four-way outer drainage valve is shown; said valve is characterized by a main stage, which, in the rest position, closes the oil passage between the ports 1 and 2 and a pilot double adjustment stage (see also Figure 4.1).

[0033] When the pilot pressure, during the pressure increase, reaches the increasing adjustment pressure, the pilot stage operates by driving the main stage which opens the passage between the ports 1 and 2.

[0034] Instead, when the pressure, during the decreasing step, reaches the decreasing adjustment value, the pilot stage operates by closing the main stage, restoring the rest condition.

[0035] Usually, such type of valve is used in circuits managing a differential load of an hydraulic accumulator.

[0036] It is connected to a fixed-displacement pump and it is connected in series to the pump itself.

[0037] Operatively, the valve determines a deliver pressure increase, in order to enable the loading of the accumulator, when the valve is in a closed rest position, in other words it is not piloted.

[0038] Instead, the valve is opened, when the pressure in the accumulator is greater than the decreasing adjustment pressure.

[0039] In such condition, the valve, also if opened, throttles the passage by forming a power loss. In order to reduce at the maximum such loss, it is necessary to have large oil passages.

[0040] A main disadvantage of this kind of valve is due to the fact that for keeping switched the same, it is necessary to have a continuous passage of oil from the port 1 to the drainage port 4 and this causes a flow rate loss and consequently a power loss.

[0041] In addition, such type of valve is not adapted to work with load sensing circuits, both with a LS pump and a pressure compensator; for said circuits (whose application is shown in Figure 1.1) it is necessary to act on the signal LS for managing the load of the accumulator and it is not necessary to have any valve in series to the pump. Particularly, it is necessary to connect the pressure main line to the line LS in order to have the greatest flow rate and pressure in order to load the accumulator.

[0042] When the accumulator is loaded, the valve must close again for interrupting the passage connecting the pump to its signal LS.

[0043] It is necessary that the sequence valve should be normally opened.

[0044] There is a second type of valve characterized by a double adjustment pressure.

[0045] The second example of the prior art is shown in Figure 2.2 which illustrates the hydraulic circuit of an example of application of the outer piloting three-way valve; (see also Figure 4.2).

[0046] Such valve substantially comprises a valve pilot stage of Figure 4.1 (described before) and it is normally coupled to a logic element. Such approach enables to obtain high work flow rates in the system, by always draining the drainage oil through the described valve in order to keep opened the logic element.

[0047] A further disadvantage for both the described approaches, is due to the fact that the sizes of the oil passages, typical of the cited circuits, formed by a main element and a pilot stage, are not adapted to manage a low flow rate signal as required by this kind of circuit. In fact, the pilot systems are instable in presence of low working flow rates and have response time greater than the one of a direct operation approach.

DISCLOSURE OF THE INVENTION

[0048] Figure 3.1 illustrates the hydraulic complete symbol of the invention in a normally closed version, while Figure 3.2 illustrates the complete hydraulic symbol of the invention in a normally opened version.

[0049] Instead, Figure 3.3 shows the hydraulic diagram of a typical application of the valve, in other words a load sensing circuit managing the differential load of an accumulator.

[0050] Figure 5.1 instead illustrates a cross-section of the valve of the invention, in a normally opened version with highlighted different details of the same.

[0051] Figure 5.2 - 5.5 illustrate the valve in the different positions which it takes during the switching.

[0052] The invention refers to a direct slide four-ways differential double adjustment valve having an outer pilot, normally opened or normally closed, wherein:

- during the pilot increasing pressure step, once it has been reached the increasing adjustment value, the valve operates by opening (if it is normally closed) or closing (if it is normally opened) the passage between the two ways dedicated to the oil passage, while
- during the pilot decreasing pressure step, once it has been reached the decreasing adjustment value, the valve returns to the starting arrangement.

[0053] The value of the adjustment increasing pressure is always greater than the one of the adjustment decreasing pressure and the ratio between such values is determined by the valve differential.

DESCRIPTION OF THE INVENTION

[0054] A cross-section of the valve, generally indicated

at 20, in a normally opened version is shown in Figure 5.1, while the corresponding hydraulic diagram is shown in Figure 3.2.

[0055] In both the figures, number 1 indicates the piloting port of the valve 20, number 2 indicates the flow rate passage inlet port, number 3 indicates the flow rate passage outlet port, and number 4 indicates the drainage port of the same, which must be connected to the drain. By observing Figure 5.1, it is possible to list the main components making up the valve 20 in the usually opened arrangement.

[0056] Particularly, number 6 indicates the cartridge of the valve in which a slide 5 moves, having a pushing area A5.

[0057] Instead, number 8 indicates the piston having a pushing area A8, moving inside the bushing 9. The bushing 9 is coaxial with respect to the cartridge, so that to enable the piston 8 and the slide 5 to axially move abutting one against the other in the inner gauged hole.

[0058] Number 7 indicates the secondary spring having the function of keeping together the two components 5 and 8 during the operation.

[0059] Number 11 indicates resilient means, in the example a main spring, acting on the outer end of the piston 8 (that is opposed to the slide 5), used for generating a force opposing to the piloting pressure, in order to obtain the desired adjustment pressure of the valve, while 12 indicates the registering screw used for precharging the spring 11.

[0060] Number 10 indicates the spring-holder, the cartridge 6 is coupled to it by a thread and a calking not shown in the figure.

[0061] In order to take the drainage signal of the port 4 in the spring side chamber D, two millings FR are made on the cartridge 6 sides at the thread used for connecting the cartridge 6 to the spring-holder 10.

[0062] The switching of the valve 20, to the normally opened arrangement, occurs when the connection between the ports 2 and 3 is interrupted due to the closure of the holes crown present on the port 2 of the cartridge 6, by the corner S2 present on the slide 5 (see also Figure 5.3).

[0063] The double adjustment of the valve is ensured by the difference between the pushing area A5 of the slide 5 and the pushing area A8 of the piston 8.

[0064] Particularly, the valve 20 differential, that is the ratio between the increasing adjustment and the decreasing adjustment, is given by the ratio between these two pushing areas.

[0065] By modifying such areas, it is possible to modify the differential of the same valve.

[0066] In the following the valve exchange operation will be described with reference to the normally opened version shown in Figure 5.1.

[0067] Figure 5.1 illustrates the valve in the rest arrangement, that is without a pressure on the piloting port 1.

[0068] In such arrangement, it is enabled the oil pas-

sage between the ports 2 and 3.

[0069] Assuming the pressure at the same port 1 increases to a value p_1 such not to pilot the valve, the same value p_1 through the hole F1 enters the chamber B, then passes in chamber C through the holes F3. Since the shoulder S3 is provided with a positive overlapping with respect to holes of the valve ports 4, the chambers B and C are isolated from the drainage of the same.

[0070] In such condition, the slide 5 is balanced because the port 1 and the chamber C are at the same pressure p_1 . The piston 8 is subjected to the pressure p_1 present in the chamber C and to the drainage pressure present in chamber D.

[0071] A force formed by the product between the pressure p_1 and the pushing area A8, opposed by the preload force of the main spring 11, is formed on the piston 8.

[0072] The piston 8 does not move until the pressure p_1 does not generate a force such to balance the spring 11 force, at the same time the slide 5 remains stopped due to the secondary spring 7 action which keeps it integral to the piston 8.

[0073] When p_1 is greater than the preload of the spring 11, the piston 8 and the slide 5, thanks to the spring 7 action, move upwardly, by reducing the port 2 opening and by reducing the shoulder S3 overlapping towards the holes of the valve 20 port 4.

[0074] When the overlapping arrangement of such shoulder due to the pressure p_1 is absent (see Figure 5.2), it is reached the switching position of the valve and the pressure p_1 equals the switching increasing pressure of valve 20.

[0075] A further slight increase of pressure p_1 in fact determines the opening of the holes of the port 4 by the shoulder S3 of the slide 5.

[0076] During this operation, the chamber B and consequently chamber C, through the holes F3 are connected to the port 4, so the pressure in chamber C decreases to the drainage pressure.

[0077] The piston 8 is now balanced (chambers C and D are both at the drainage pressure), while the slide 5 is at pressure p_1 at the port 1 and at the drainage pressure in chamber C.

[0078] The force opposing the main spring 11 increases because with the same pressure p_1 , the pushing area passes from the value A8 of the piston to the greater value A5 of the slide.

[0079] Therefore, the system equilibrium fails and the slide 5 is moved to the stop with the piston 8.

[0080] To summarize, the increasing pilot pressure value equals the preload force of the spring seen in the Figure 5.2 arrangement, divided by the piston area A8; as soon as it is passed this position, it is lost the equilibrium condition on the slide so that it is quickly pushed to the stop.

[0081] It is to be noted that the exchange operation is generated when the port 2 is still opened (see Figure 5.2).

[0082] Instead, at the stop, this port is closed (see Figure 5.5).

[0083] It is very important to note that both in the rest position and in the stop position, the piloting port 1, port 2, and port 3 are isolated from the drainage port. Therefore, it is not necessary to have an oil passage for keeping piloted the valve 20.

[0084] The port 1 is connected to the drainage only during the switching from the position shown in Figure 5.2 to the one shown in Figure 5.4.

[0085] It is to be noted that once it is passed the position in Figure 5.2, that is the starting switching positions, the valve 20 does not find a next equilibrium position until it reaches the stop position (see Figure 5.5), so that the exchange time is very low.

[0086] Therefore, the presence of the drainage port 4 is provided for taking the pressure of the same drainage in chamber C in order to promote the described switching of the valve and to avoid the counter pressure in chamber D of the spring space.

[0087] The valve, having reached the stop position, remains in this position until the port 1 pressure reaches the decreasing pressure value of the valve 20.

[0088] Such pressure value, as it will be shown, equals the spring preload force seen in the Figure 5.4 arrangement, divided by the slide area A8.

[0089] More specifically, during the decreasing pressure step at the port 1 of the valve, there are not any changes until it is reached the arrangement shown in Figure 5.4. In such condition, the valve port 1 is still isolated (the overlapping is absent) both from chamber B and chamber C which are at the drainage pressure.

[0090] Therefore, the slide 5 is pushed by the pressure p_1 on the area A5 and is balanced by the spring 11 force. Since area A5 is greater than the piston area A8, the equilibrium pressure is less than the adjustment increasing pressure of the valve 20.

[0091] As soon as the shoulder S1 opens the port 1, the pressure in chambers B and C starts to reach again the value p_1 , so that the pushing area contrasting the spring 11 is again equal to A8, that is it is the area of the piston 8.

[0092] The pressure level is less than the value of the increasing adjustment, so that, once again, the slide-piston assembly is not in equilibrium, because the spring 11 force is greater than the pressure p_1 value (it is equal to the decreasing adjustment pressure) multiplied by the area of the piston A8.

[0093] This fact determines that the valve 20 is pushed in the rest position shown in Figure 5.1.

[0094] Also in this case, the switching operation is generated when the port 2 is still closed (see Figure 5.4). Instead, at rest, this port is opened (see Figure 5.1). The described switching operation of the normally opened valve 20 is the same as the one of the normally closed valve 20, the difference being that the passage between the ports 2 is located at the opposed logic state in each arrangement of the valve (see Figures 5.1 - 5.5). During the switching operation, there are other forces beside the forces of the spring 11 and pressure p_1 . Such forces are

the flow forces generated near the openings or near the closure of the openings.

[0095] For reducing the effect, it is possible to introduce some flaps which are segments of the slide having an increased diameter.

[0096] Figure 5.1 illustrates the flap D used for reducing the effect of the flow forces at the opening of the port on the port 2 of the valve 20.

[0097] The flow forces effect can also appear at the opening of the shoulders S1 and S3.

[0098] Anyway, it is possible to position flaps also on the shoulders S1 and S3 in order to avoid such effects.

[0099] A further factor occurring during the switching operation, is shown by the sizes of the holes F1 and F2 present on the slide 5.

[0100] Such holes modify the speed at which the chambers B and C can modify their pressure level, particularly by passing from the drainage pressure to the one of the piloting port 1.

[0101] By changing the size of such holes it is possible to act on the switching speed by promoting the increasing steady one of the pressure, rather than the steady decreasing one or vice versa.

[0102] A further possible action enabling to modify such switching times consists of inserting a further dowel in position G in Figure 5.1, which for the sake of simplicity has been represented by a broken line square inside the conduit to chamber B.

[0103] By changing the size of holes F1, F2 and/or dowel G, enables to optimize the switching times in order to improve the system stability in which the valve is inserted.

VARIANTS OF THE EMBODIMENT

[0104] It is possible to substitute said two separated components, the slide 5 and the piston 8 for a single component.

[0105] The main advantage of maintaining separated the components is due to the fact that it is not necessary to have a coaxial thrust between the inner diameter of the bushing 9 and the cartridge 6, the slide 5 and the piston 8 must freely slide in these areas.

[0106] A further advantage is due to the fact that the grinding of a single component on two diameters is certainly more complex than the one on two separate components.

[0107] The disadvantage of the approach shown in Figure 5.1 is represented by the necessity of using the secondary spring 7 which would be not necessary if the components 5 and 8 are united, that is integral.

[0108] A further constructive variant can be implemented by inserting drilled dowels inside the slide 5 instead of the adjusted holes F1, F2 (adapted to communicate the inner chambers B and C with the ports 1 and 4), for more easily adapting the valve 20 to the different needs of the system in which the valve is located, without modifying the shape of the slide.

Claims

1. Outer pilot double adjustment differential four-ways direct slide (5) valve (20), normally opened or normally closed, of the type comprising: a piloting port (1), inlet, outlet and flow rate passage ports (2, 3), a drainage port (4), connected to a drain; said ports (1, 2, 3, 4) being made in a cartridge (6) of valve (20) in which the slide (5) is freely movable inside a corresponding hole having an area (A5); a piston (8), having a pushing area (A8), in turn axially slidable inside a bushing (9) coaxial with said cartridge (6); resilient means (11) acting against said piston (8) on the side opposite to the slide (5), whose preload determines the valve (20) adjustment; said valve (20) defining two limit positions, in which:

- a. a rest position, in which the connection between the ports (2) and (3) is opened, when the valve is normally opened or closed when the valve is normally closed,
- b. a stop, in which the connection between the ports (2) and (3) is closed in case the valve is normally opened or opened in case the valve is normally closed;

characterized by the fact at both said rest and stop positions, the piloting port (1) and ports (2) and (3) are isolated from the drainage port (4).

2. Valve (20) according to claim 1, **characterized by** the fact the port (1) is connected to the drainage (4) only during the switching step which starts:

- a. during the increasing pilot pressure step when the pilot pressure at the port (1) reaches the increasing adjustment pressure value, equal to the value of the spring (11) preload force divided by the area (A8) of the piston (8),
- b. during the pilot decreasing pressure step, when the pressure at the piloting port (1) reaches the decreasing adjustment pressure value, equal to the spring (11) preload force divided by the area (A5) of the slide (5), once it has been passed the switching starting position, said valve (20) does not find a successive equilibrium position until it reaches, during the increasing pressure step, the stop position, during the decreasing pressure step, the rest position; the effective exchange position, that is when it is opened or closed the connection between the ports (2) and (3), it is always inside this transition step.

3. Valve (20) according to claim 1 and 2, **characterized by** the fact the adjustment increasing pressure value is always greater than the one of the decreasing adjustment pressure and the ratio between such values

equals the valve differential, which can be computed also as the ratio between the slide (5) pushing area (A5) and the piston (8) pushing area (A8).

4. Valve (20) according to claim 1 and 2, **characterized by** the fact the switching operation, during the increasing steady state of the pressure, rather than in the decreasing steady state, is adjusted, with reference to the operation speed, by the size of holes (F1) and (F2), on the slide (5), adapted to communicate the inner chambers (B) and (C) with the ports (1) and (4). 5
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5. Valve (20) according to claim 4, **characterized by** the fact it comprises a further dowel (G) inside the chamber (B) conduit. 15
6. Valve (20) according to claim 4 or 5, **characterized by** the fact it comprises drilled dowels inside the slide (5) instead of the adjusted holes (F1, F2), for more easily adapting the valve (20) to the different needs of a plant in which it is located the valve without modifying the shape of the slide (5). 20
7. Valve (20) according to claim 1, **characterized by** the fact the slide (5) and piston (8) are separate elements and a secondary spring (7) keeps integral said two components (5) and (8) during the operation. 25
30
8. Valve (20) according to claim 1, **characterized by** the fact the slide (5) and piston (8) are combined and integral in a single component.
9. Valve (20) according to claim 1, **characterized by** the fact it further comprises flaps for limiting the flow forces generating, during the exchange operation, near the opening of the ports or near the closing of the same. 35
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10. Valve (20) according to claim 9, **characterized by** the fact said flaps are segments having an increased diameter on the slide (5). 45
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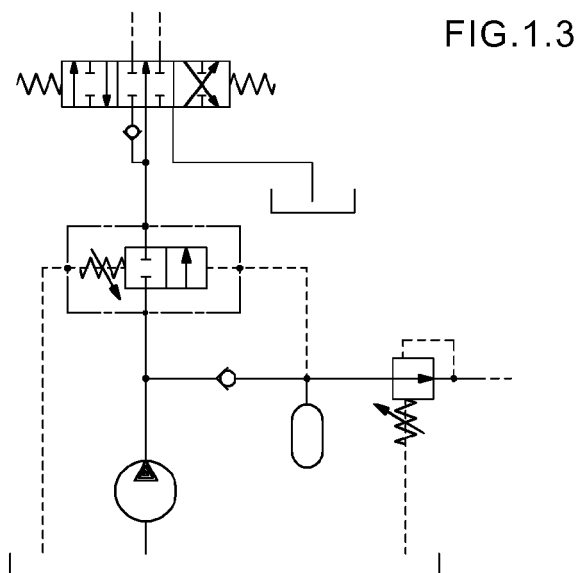
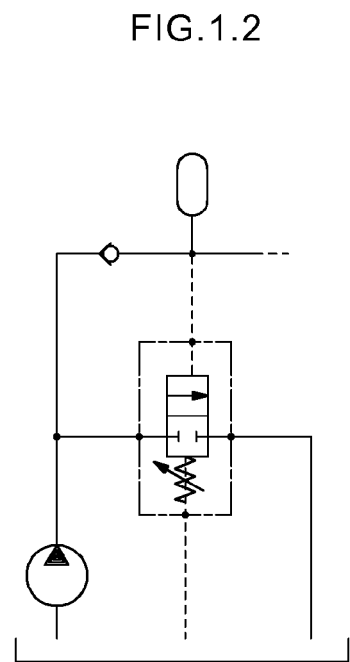
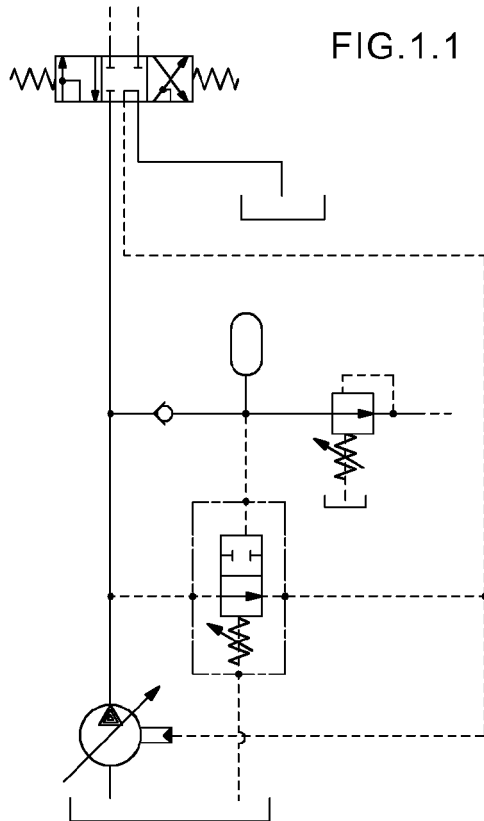


FIG.2.1

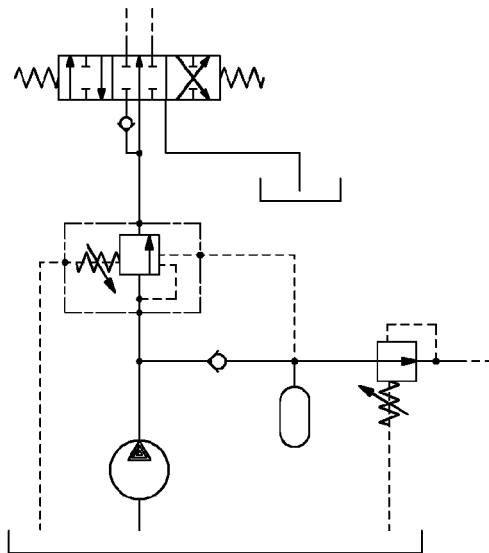


FIG.2.2

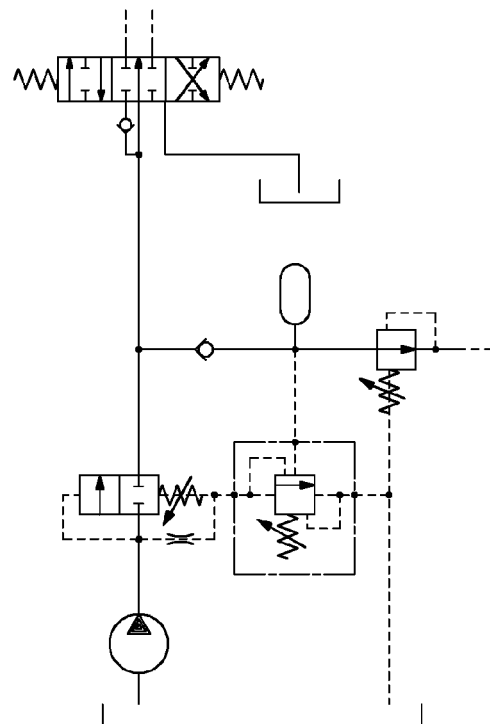


FIG.3.1

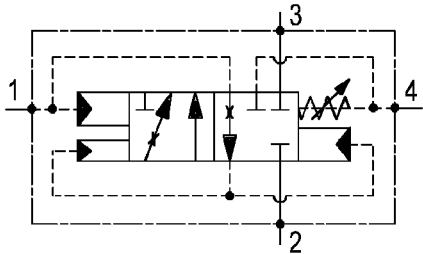


FIG.3.2

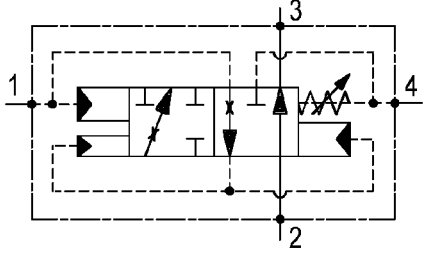


FIG.3.3

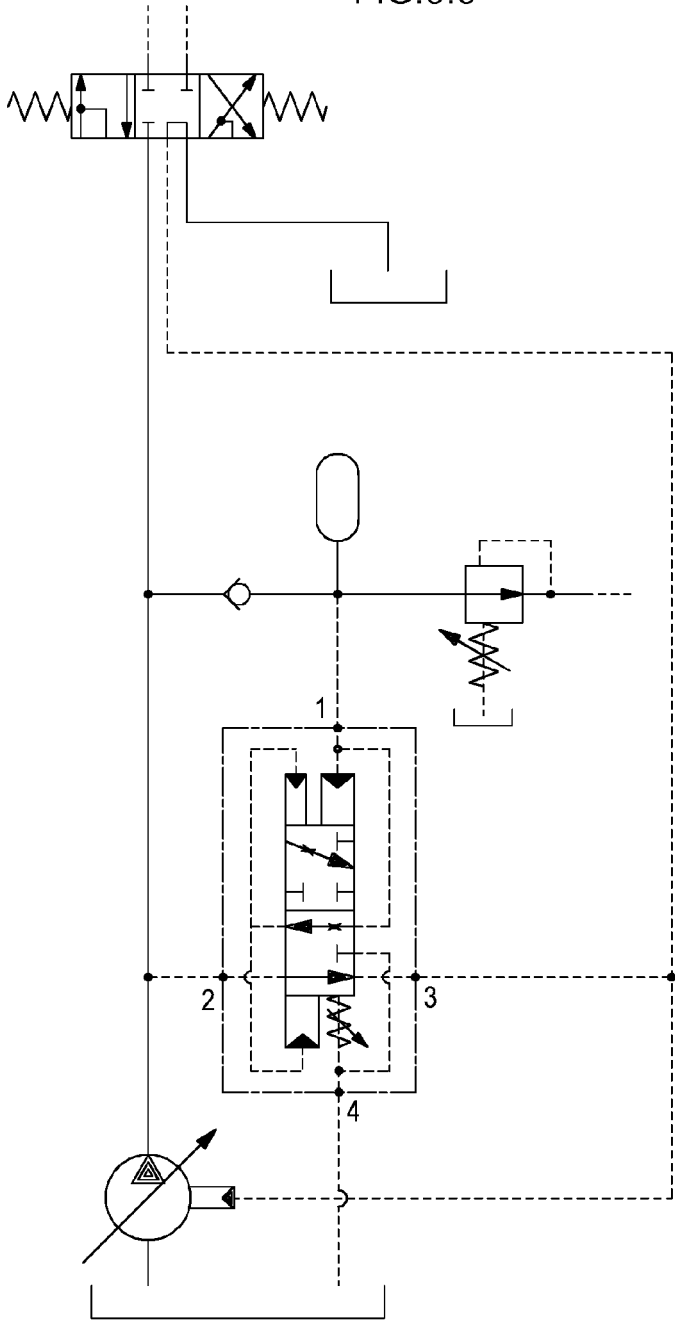


FIG.4.1

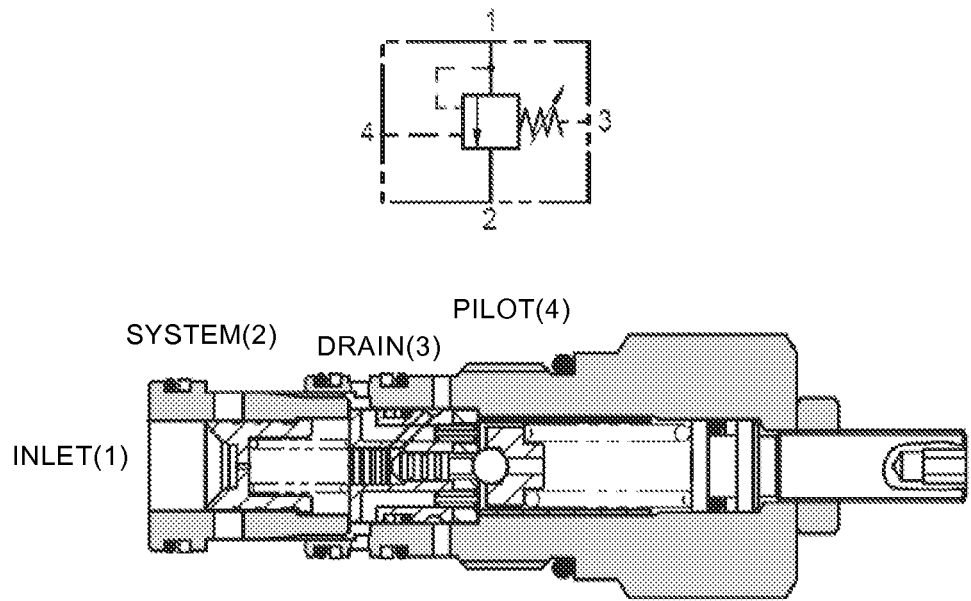


FIG.4.2

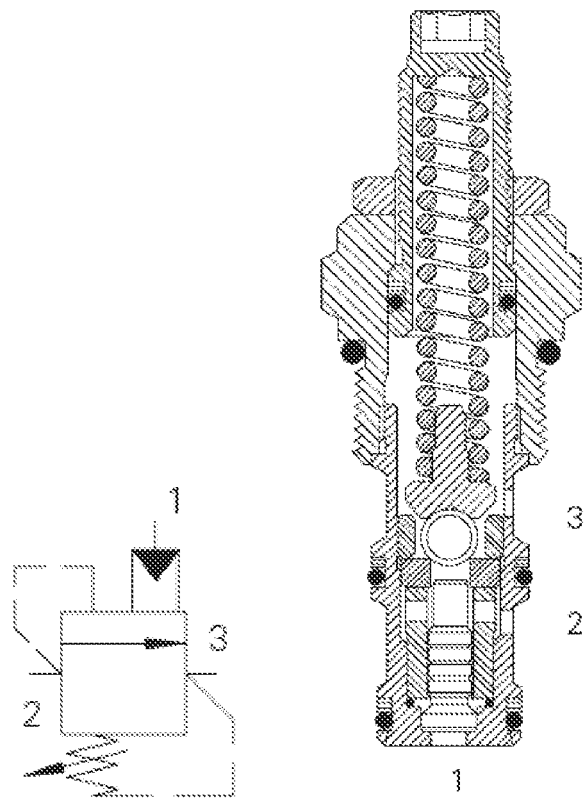


FIG.5.1

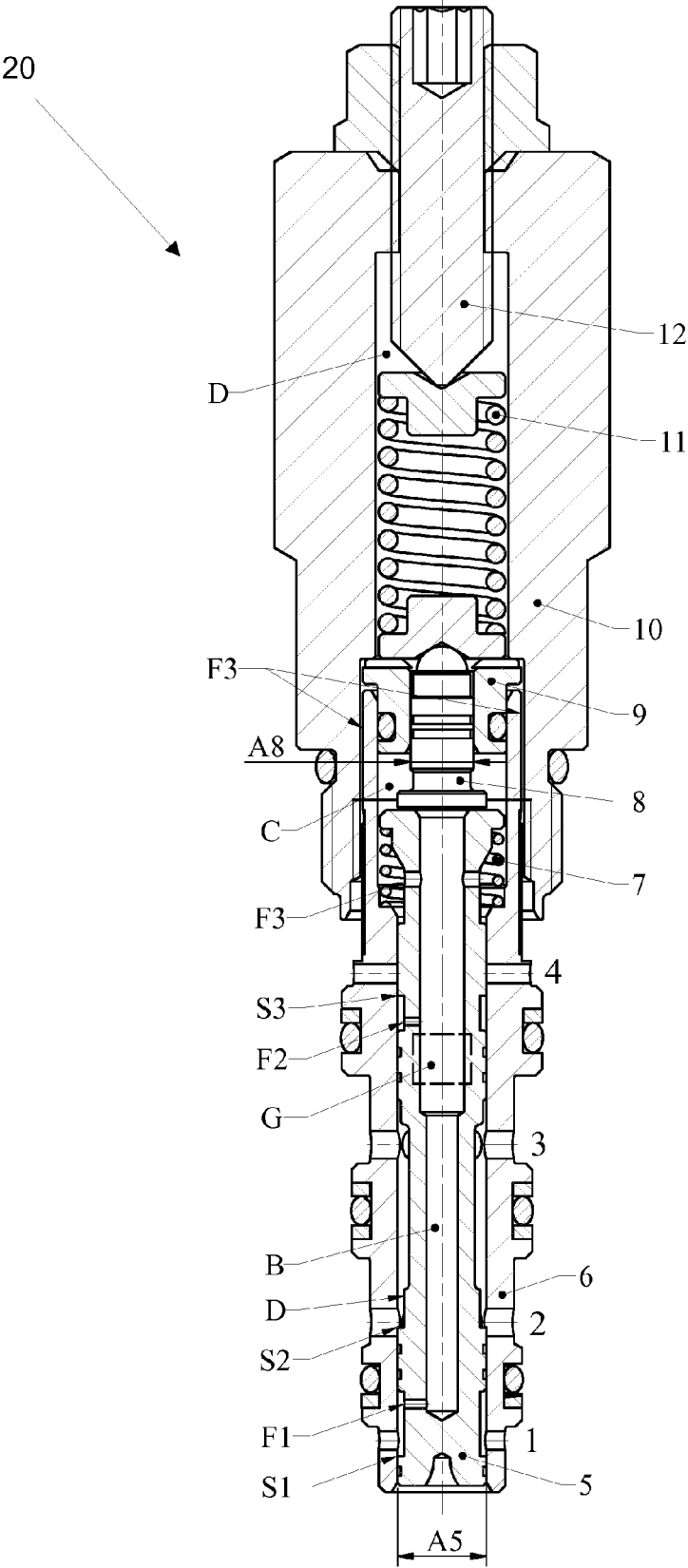


FIG.5.2

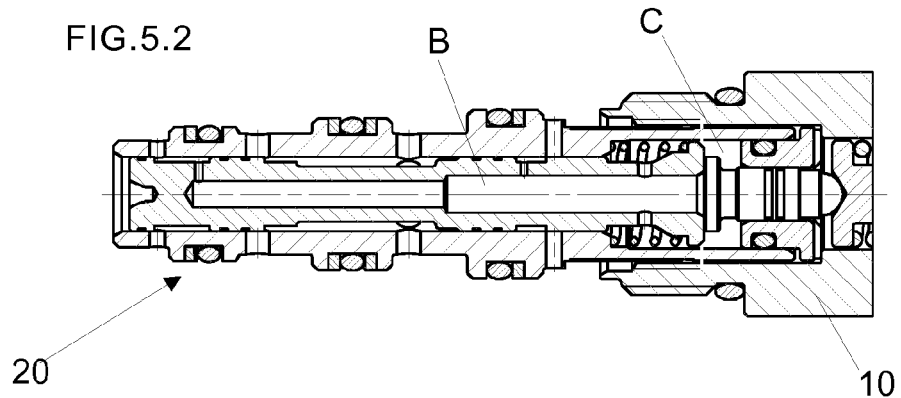


FIG.5.3

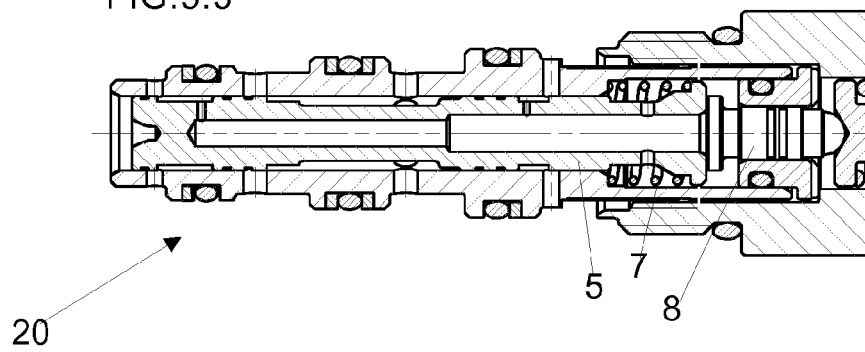


FIG.5.4

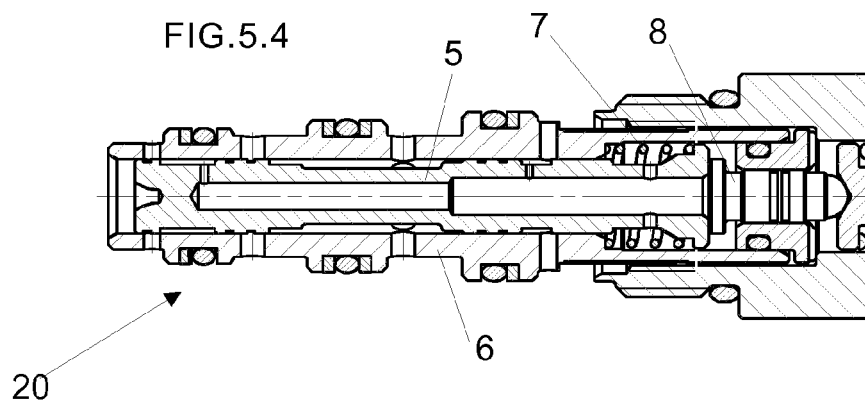
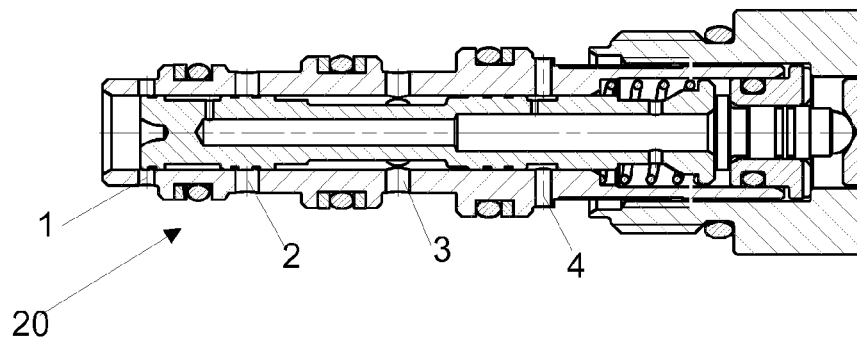


FIG.5.5





EUROPEAN SEARCH REPORT

Application Number
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Place of search Munich		Date of completion of the search 19 July 2011	Examiner Busto, Mario
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