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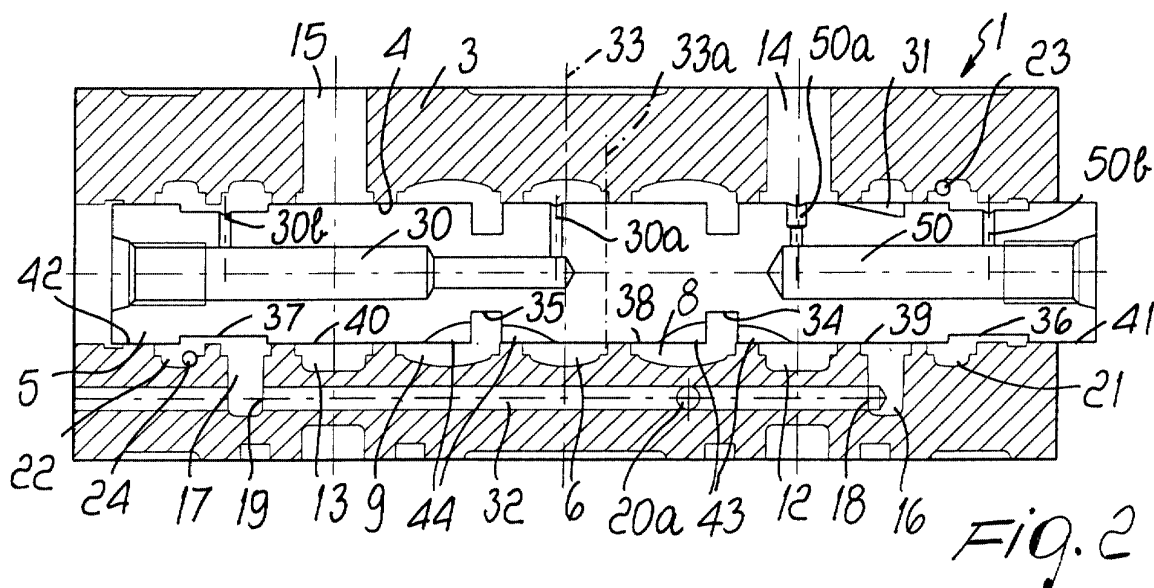
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(54) **Hydraulic control device**

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Description

[0001] The present invention relates to a control device, for the actuation of a hydraulic user device, with an input pressure compensator, having high operating stability. More particularly, the device according to the present invention is designed to be used in hydraulic systems for the actuation of user devices constituted by double-acting hydraulic cylinders or by hydraulic motors or user devices with two actuation branches which are selectively connected to a pressurized branch of the hydraulic circuit and to the discharge branch, for example in machines for lifting or moving a load.

[0002] Hydraulic circuits, generally fed by a single pump having an adequate flow-rate, for the actuation of a plurality of user devices which usually have different loads or require mutually different pressures for their actuation, are known.

[0003] It should be noted that the various user devices generally have to be controlled fully independently, i.e., variations in the resisting load or in the actuation of one user device must not affect the actuation of the other user devices. Each user device is usually controlled by means of a bidirectional pilot valve which selectively connects the two hydraulic feed branches of the corresponding user device to the pressurized branch of the main circuit or to the discharge branch or closes said two feed branches of the user device being considered.

[0004] In order to achieve correct operation of the various user devices, preventing the flow delivered by the pump from being predominantly directed toward the user device that has the lowest load to the detriment of the user devices that have a higher load, a pressure compensator is arranged on the branch of the circuit that connects the pressurized branch, i.e., the delivery of the pump, to the pilot valve of each user device. Said pressure compensator is meant to maintain a constant difference in pressure between the pressurized branch of the hydraulic circuit, which is connected to the delivery of the pump, and the operating pressure that overcomes the load, by means of the ΔP that forms across the distribution rod or slide of the pilot valve.

[0005] The operating pressure that overcomes the load or brakes it acts, together with a spring, so as to increase the aperture of the pressure compensator in contrast with the action of the pressure on the feed branch of the pilot valve.

[0006] In practice, the two branches that feed the user device, by way of the actuation of the pilot valve, are connected respectively to the pressurized branch that enters the pilot valve and to the discharge branch of the circuit; the branch of the user device that is connected to the pressurized branch is connected, through said pilot valve, to a duct which enters the pressure compensator and through which the working pressure is transmitted to the pressure compensator.

[0007] The pressure transmitted through said duct from the branch of the user device to the pressure com-

pensator constitutes a hydraulic signal known as "load sensing" or LS, which in this manner drives the pressure compensator.

[0008] In some applications, the actuation of the user device being considered must be interrupted when the pressure along an actuation branch of said user device reaches a preset maximum value. In order to meet this requirement, the duct LS is connected to a maximum-pressure valve which connects the duct LS and therefore the corresponding user device actuation branch to the discharge branch of the circuit, or more generically to a discharge, when said preset maximum pressure is reached.

[0009] In some cases it must also be possible to interrupt the actuation of the user device being considered when two different maximum pressures are reached on the two actuation branches of the user device.

[0010] Specific devices have been devised in order to meet these requirements; one of them is disclosed in patent No. 1,281,708 in the name of this same Applicant.

[0011] In some operating conditions, such as for example during the lowering of a load, i.e., when the hydraulic user device, constituted by a hydraulic cylinder or by a hydraulic motor, acts mainly as a brake, the hydraulic user device must be actuated with low pressures and with a reduced flow-rate.

[0012] In such circumstances, with devices provided with a pressure compensator on the input of the bidirectional pilot valve that controls the actuation of the hydraulic user device, instability problems can arise in the form of pulsating pressures which generate intense oscillations on the mechanical structures of said machines, such as to compromise their functionality.

[0013] The aim of the present invention is to solve the above-described problems by providing a hydraulic control device, for the actuation of a hydraulic user device, with an input pressure compensator, which achieves high operating stability during actuation.

[0014] Within this aim, an object of the invention is to provide a device which ensures operating stability even when the hydraulic user device must be actuated with low pressures and reduced flow-rates.

[0015] Another object of the invention is to provide a device which can be obtained, with modest modifications which are simple to implement, from conventional devices provided with a pressure compensator on the input of the bidirectional pilot valve that controls the actuation of the hydraulic user device.

[0016] This aim and these and other objects which will become better apparent hereinafter are achieved by a hydraulic control device, for the actuation of a hydraulic user device, with input pressure compensator, comprising a bidirectional pilot valve, which can be actuated in order to connect one actuation branch of a user device to a pressurized branch of a hydraulic circuit and the other actuation branch of the user device to a discharge branch of the hydraulic circuit, and a pressure compen-

sator, which is arranged on the pressurized branch of the hydraulic circuit that enters said pilot valve, said pilot valve comprising a valve body in which a substantially cylindrical seat is provided which slidably accommodates a slide, said seat having, along its axial extension, larger-diameter regions which are alternated with smaller-diameter regions which are slidably coupled to said slide; said larger-diameter regions forming in the valve body, around said slide, a plurality of chambers which comprise a first chamber in a substantially central position, which is connected to a first port which is connected to the pressurized branch of the hydraulic circuit; a second chamber and a third chamber being formed laterally on opposite sides with respect to said first chamber and being connected respectively to a second port which is connected to a user device actuation branch and to a third port which is connected to another user device actuation branch; a fourth chamber and a fifth chamber being formed laterally to said second chamber and said third chamber, on the opposite side with respect to said first chamber, and being connected respectively to a fourth port and a fifth port which are connected to the discharge branch of the hydraulic circuit; a sixth chamber and a seventh chamber being formed laterally to said fourth chamber and to said fifth chamber, on the opposite side with respect to said first chamber, and being connected respectively to a sixth port and a seventh port which are connected to a control duct which is connected to said pressure compensator for its actuation in contrast with the pressure along said pressurized branch which enters the pilot valve; said slide being movable on command into three positions: a first position, in which it connects said first chamber to said second chamber and said third chamber to said fifth chamber; a second position, in which it connects said first chamber to said third chamber and said second chamber to said fourth chamber; and a third position, or idle position, in which it interrupts the connection of said first chamber to said second chamber and to said third chamber; characterized in that said sixth chamber is connected to said seventh chamber and in that said slide has at least one first internal duct which connects said first chamber to said sixth chamber or to said seventh chamber when the slide is in said first position or in said second position, said slide further having at least one first passage which connects said seventh chamber to said fifth chamber or said sixth chamber to said fourth chamber when the slide is in said first position or in said second position.

[0017] Further characteristics and advantages of the invention will become better apparent from the description of two preferred but not exclusive embodiments of the device according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figures 1 to 6 are views of a first embodiment of the device according to the invention, and more specif-

ically:

Figure 1 is an axial sectional view of the pilot valve, with the slide in the first position;

Figure 2 is an axial sectional view of the pilot valve, with the slide in the second position;

Figure 3 is an axial sectional view of the pilot valve, with the slide in the third position;

Figure 4 is a schematic view of the device according to the invention, with the slide of the pilot valve in the first position;

Figure 5 is a schematic view of the device according to the invention, with the slide of the pilot valve in the second position;

Figure 6 is a schematic view of the device according to the invention, with the slide of the pilot valve in the third position;

Figures 7 to 12 illustrate a second embodiment of the device according to the invention, and more specifically:

Figure 7 is an axial sectional view of the pilot valve, with the slide in the first position;

Figure 8 is an axial sectional view of the pilot valve, with the slide in the second position;

Figure 9 is an axial sectional view of the pilot valve, with the slide in the third position;

Figure 10 is a schematic view of the device according to the invention, with the slide of the pilot valve in the first position;

Figure 11 is a schematic view of the device according to the invention, with the slide of the pilot valve in the second position;

Figure 12 is a schematic view of the device according to the invention, with the slide of the pilot valve in the third position;

Figure 13 is a hydraulic diagram for the actuation of two user devices, one of which is actuated by means of the device according to the invention.

[0018] With particular reference to Figures 1 to 6, the device according to the invention, in its first embodiment, comprises a bidirectional pilot valve, generally designated by the reference numeral 1, which can be actuated in order to connect one actuation branch A or B of a hydraulic user device to a pressurized branch P of a hydraulic circuit and the other actuation branch B or A of the user device to a discharge branch T of the hydraulic circuit.

[0019] The device also comprises, in a per se known manner, a pressure compensator 2 which is arranged on the pressurized branch of the hydraulic circuit that enters the pilot valve 1. The portion of the pressurized branch that runs from the pressure compensator 2 to the pilot valve 1 has been designated by P_1 .

[0020] The pilot valve 1 comprises a valve body 3 in which a substantially cylindrical seat 4 is present which accommodates, so that it can slide axially, a slide 5 which is arranged coaxially in the seat 4.

[0021] The seat 4 has, along its axial extension, larg-

er-diameter regions which are alternated with smaller-diameter regions; said smaller-diameter regions are coupled slidingly and hermetically to regions of the side wall of the slide 5. Said larger-diameter regions form, in the body 3 of the pilot valve 1, around the slide 5, a plurality of chambers which comprise a first chamber 6, in a substantially central position, which is connected to a first port 7 which is formed in the valve body 3 and is connected to the pressurized branch P_1 of the hydraulic circuit in output from the pressure compensator 2.

[0022] A second chamber 8 and a third chamber 9 are formed laterally, on opposite sides with respect to the first chamber 6, and are connected respectively to a second port 10, which is formed in the body 3 of the pilot valve 1 and is connected to the actuation branch A of the user device, and to a third port 11, which is formed in the body 3 of the pilot valve 1 and is connected to the actuation branch B of the other user device.

[0023] A fourth chamber 12 and a fifth chamber 13 are formed laterally to the second chamber 8 and to the third chamber 9, on the opposite side with respect to the first chamber 6, and are respectively connected to a fourth port 14 and to a fifth port 15, which are formed in the body 3 of the pilot valve 1 and are connected to the discharge branch T of the hydraulic circuit.

[0024] A sixth chamber 16 and a seventh chamber 17 are formed laterally to the fourth chamber 12 and to the fifth chamber 13, on the opposite side with respect to the first chamber 6, and are respectively connected to a sixth port 18 and to a seventh port 19 which are formed in the body 3 of the pilot valve 1 and are connected to the inlet 20a of a control duct 20, which is in turn connected to the pressure compensator 2 for its actuation in contrast with the pressure along the pressurized branch P_1 that enters the pilot valve 1.

[0025] An eighth chamber 21 and a ninth chamber 22 are formed laterally to the sixth chamber 16 and to the seventh chamber 17, on the opposite side with respect to the first chamber 6, and are respectively connected to an eighth port 23 and to a ninth port 24 which are formed in the body 3 of the pilot valve 1 and are respectively connected to a first adjustment duct 25 and to a second adjustment duct 26.

[0026] The slide 5 can move on command along its own axis, inside the seat 4, into three operating positions: a first position, in which it connects the first chamber 6 to the second chamber 8 and the third chamber 9 to the fifth chamber 13, so as to connect the actuation branch A of the user device to the pressurized branch of the hydraulic circuit and the actuation branch B of the user device to the discharge branch of the hydraulic circuit; a second position, in which it connects the first chamber 6 to the third chamber 9 and the second chamber 8 to the fourth chamber 12, so as to connect the actuation branch B of the user device to the pressurized branch of the hydraulic circuit and the actuation branch A of the user device to the discharge branch of the hydraulic circuit; and a third position or idle position, in

which it interrupts the connection of the first chamber 6 to the second chamber 8 and to the third chamber 9.

[0027] According to the invention, the sixth chamber 16 is connected, by means of a connecting duct 32, to the seventh chamber 17 and the slide 5 has at least one first internal duct 30 which connects the first chamber 6 to the sixth chamber 16 or to the seventh chamber 17 when the slide 5 is in the first position or in the second position; the slide 5 further has a first passage 31 which connects the seventh chamber 17 to the fifth chamber 13 or the sixth chamber 16 to the fourth chamber 12 when the slide 5 is in the first position or in the second position.

[0028] Moreover, in the first position the slide 4 connects the sixth chamber 16 to the eighth chamber 21; in the second position, said slide connects the seventh chamber 17 to the ninth chamber 22.

[0029] The chambers 6, 8, 9, 12, 13, 16, 17, 21 and 22 are arranged symmetrically with respect to an imaginary central plane 33 which is perpendicular to the axis of the seat 4. The slide 5 has a substantially cylindrical active region, provided with mutually spaced circumferential narrowings 34, 35, 36 and 37, which is designed to interact with said chambers.

[0030] More particularly, the circumferential narrowings 34, 35, 36 and 37 delimit, in the active region of the slide, a central portion 38, two mid-lateral portions 39 and 40, and two end-lateral portions 41 and 42. Recesses 43, 44 straddle the circumferential narrowings 34 and 35, which are located respectively between the central portion 38 and the mid-lateral portion 39 and between the central portion 38 and the mid-lateral portion 40. When the slide 5 is in the first position, the recesses 43 connect the first chamber 6 to the second chamber 8 and the recesses 44 connect the third chamber 9 to the fifth chamber 13, while when the slide 5 is in the second position, the recesses 43 connect the second chamber 8 to the fourth chamber 12 and the recesses 44 connect the first chamber 6 to the third chamber 9.

[0031] The recesses 43, 44 are shaped like a cusp which gradually widens toward the outer surface of the slide and also gradually widen from the mid-lateral portions 39, 40 and from the central portion 38 toward the circumferential narrowings 34 and 35, which they straddle.

[0032] In the illustrated embodiment, in which the internal duct 30 lies in the region of the slide 5 that is occupied by the central portion 38, by the mid-lateral portion 40 and by the end-lateral portion 42, said internal duct 30 has an inlet 30a on the central portion 38 and an outlet 30b at the circumferential narrowing 37.

[0033] The first passage 31 is constituted by a choke which is formed in the mid-lateral portion 39 of the slide 5 and preferably has a cross-section which gradually tapers toward the central portion 38 of the slide 5.

[0034] Conveniently, in the first embodiment, in the slide 5 there is a second internal duct 50 which connects the second chamber 8 to the sixth chamber 16 when the

slider 5 is in the first position and connects the fourth chamber 12 to the eighth chamber 21 when the slide 5 is in the second position.

[0035] According to requirements, the position of the first internal duct 30 might be switched with the position of the second internal duct 50 symmetrically with respect to the imaginary median plane 33a of the slide 5. Said median plane 33a coincides with the median plane 33 of the seat 4 when the slide 5 is in the third position. In this case, the inlet 30a would again be formed in the central portion 38, but so as to be located in the second chamber 8 when the slide 5 is in the first position, and the outlet 30b would be located at the circumferential narrowing 36; in this case, furthermore, the second internal duct 50 would have an inlet 50a on the mid-lateral portion 40, so as to be located in the fifth chamber 13 when the slide 5 is moved into the first position, and an outlet 50b at the circumferential narrowing 37, so as to be located in the third chamber 9, connecting it to the seventh chamber 17, when the slide 5 is moved into the second position.

[0036] The pressure compensator 2 is pushed into the closure position by the pressure along P_1 in contrast with the action of a spring 60. The control duct 20 is connected to the pressure compensator 2 so as to act thereon concordantly with the action of the spring 60 and therefore so as to open the pressure compensator.

[0037] With particular reference to Figures 4 to 6, the first adjustment duct 25, along which the pressurized hydraulic signal LS_A , which corresponds to the actuation pressure of the branch A of the user device, is transmitted, is connected to the discharge branch T of the hydraulic circuit through a maximum-pressure valve 61 which connects the adjustment duct 25 to the discharge branch T when a pressure which is at least equal to the calibration pressure of the valve 61 occurs along the adjustment duct 25.

[0038] The second adjustment duct 26, along which the pressurized hydraulic signal LS_B , which corresponds to the actuation pressure of the branch B of the user device, is transmitted, is also connected to the discharge branch T of the hydraulic circuit through a maximum-pressure valve 62 which connects the adjustment duct 26 to the discharge branch T when a pressure which is at least equal to the calibration pressure of the valve 62 occurs along the adjustment duct 26.

[0039] Advantageously, the adjustment ducts 25 and 26 each have a branch which is connected to the discharge branch T by means of respective controllable electric valves 63 and 64. The electric valves 63 and 64, in normal operating conditions, are energized or closed and thus prevent the connection of the adjustment ducts 25 and 26 to the discharge branch T and can be deenergized in order to provide said connection when conditions occur which require an interruption of the actuation of the user device during actuation on the branch A or on the branch B.

[0040] The circuit shown in Figures 4 to 6 is completed

by a choke 65 which is arranged on the control duct 20 and by a branch 20b of the control duct 20 which enters a switching or selection valve 66. The outlet of the switching valve 66, as shown in Figure 13, is connected to a flow/pressure regulator 67, which is arranged along a branch 68 for connecting the pressurized branch P to the discharge branch T of the hydraulic circuit. More particularly, the flow/pressure regulator 67 is kept in the open position by the pressure that is present in the pressurized branch P in contrast with the action applied by a spring 69. The signal LS that arrives from the control duct 20 acts on the flow/pressure regulator 67 concordantly with the action of the spring 69, which thus acts so as to cause the closure of the flow/pressure regulator 67, as will become better apparent hereinafter.

[0041] Figure 13 illustrates a hydraulic circuit which serves two user devices: respectively, a first user device, designated by the reference numeral 90, which is controlled by means of a device according to the invention, and a second user device, generally designated by the reference numeral 91, which is controlled by means of a device of the type disclosed in the previously cited patent No. 1,281,708.

[0042] The signal LS that arrives from the first device 90, in output from the switching or selection valve 66, passes through a second switching or selection valve 70, which also receives in input the signal LS of the device 91, and then reaches the flow/pressure regulator 67. The pump that feeds the hydraulic circuit is designated by the reference numeral 71. As regards the other elements shown in Figure 13, since they are commonly used in the field of hydraulic circuits, their detailed description is omitted.

[0043] It should be noted that according to requirements one or both of the maximum-pressure valves 61 and 62 may be absent, and one or both of the electric valves 63 and 64 may also be absent.

[0044] Operation of the device in its first embodiment is as follows.

[0045] It is noted first of all that the device, in this first embodiment, is particularly suitable for use if one requires an actuation of the user device which is similar to the actuation that can be obtained with a proportional directional valve in the feed of the branch A of the user device, such as for example during the lifting of a load, and if it is necessary to actuate the branch B of the user device with a low pressure and a reduced flow-rate, such as for example during the lowering of a load.

[0046] When the slide 5 is moved from the third position or idle position (Figures 3 and 6) to the first position (Figures 1 and 4), the first chamber 6 is connected to the second chamber 8, the sixth chamber 16 is connected to the eighth chamber 21, and the third chamber 9 is connected to the fifth chamber 13. In this operating condition, further, the duct 50 connects the second chamber 8 to the sixth chamber 16, while the duct 30 connects the third chamber 9 to the ninth chamber 22. In this manner, the branch P_1 is connected to the branch A. It should

be noted that when the slide 5 is in this position, the branch A and the branch P_1 are connected to the control duct 20, along which the signal LS is transmitted, and to the first adjustment duct 25, along which the hydraulic signal LS_A is transmitted.

[0047] The branch B and the second adjustment duct 26, along which the hydraulic signal LS_B is transmitted, are connected to the discharge branch T. In this operating condition, the pressure compensator 2 operates normally.

[0048] When instead the slide 5 is moved from the idle position to the second position (Figures 2 and 5), the first chamber 6 is connected to the third chamber 9, the seventh chamber 17 is connected to the ninth chamber 22, and the second chamber 8 is connected to the fourth chamber 12. The duct 30 connects the first chamber 6 to the seventh chamber 17, the duct 50 connects the fourth chamber 12 to the eighth chamber 21, while the passage 31 connects the sixth chamber 16 to the fourth chamber 12. In this operating condition, the pressure of the branch P_1 is transmitted to the seventh chamber 17 and from there to the pressure compensator 2, so that said pressure acts concordantly with the spring 60 in order to maintain the pressure compensator 2 in the open position or in any case increase its aperture. Owing to the fact that the seventh chamber 17 is connected to the sixth chamber 16 through the connecting duct 32, part of the flow that enters the first chamber 6 is sent to the discharge branch T by means of the passage 31. The extent of the flow discharged through the passage 31 is a function of the position of the slide 5 as a consequence of the particular shape of said passage 31. Owing to the fact that the pressure transmitted along the control duct 20 to the pressure compensator 2 is equal to, or slightly lower than, the pressure along the branch P_1 , the compensator 2 is kept in a fully open position or in any case in a partly open position in which its aperture is greater than it would be if the actuation duct 20 were connected to the branch B of the user device.

[0049] Moreover, the signal LS, which is identical to or slightly lower than the pressure P_1 , is sent through the switching valves 66 and 70 to the flow/pressure regulator 67, assisting the spring 69 in causing or increasing the closure of said flow/pressure regulator 67. In this manner, the working pressure of the pump 71 is considerably higher than the pressure required to feed the branch B of the user device. Higher operating stability is thus achieved even if the user device, in order to be actuated, requires low pressures and reduced flow-rates.

[0050] In the second embodiment, shown in Figures 7 to 11, the device again comprises a bidirectional pilot valve, generally designated by the reference numeral 1a, whose body is provided substantially like the body 3 of the pilot valve 11. For this reason, the body of the pilot valve 1a, the seat for the slide 5a, the various chambers formed along said seat, and the ports for connecting various ducts have been designated by the same

reference numerals used to designate the similar elements described with reference to the first embodiment. The slide 5a, as regards its side wall, is provided in the same manner as described with reference to the slide 5 of the first embodiment. For this reason, the central portion, the mid-lateral portions, the end-lateral portions, the circumferential narrowings and the recesses arranged at the circumferential narrowings located at the sides of the central portion have been designated by the same reference numerals used in Figures 1 to 3.

[0051] An internal duct, again designated by the reference numeral 30, is formed in the slide 5a, as in the first embodiment.

[0052] Differently from the slide 5, the slide 5a has a second internal duct 80 which has an inlet 80a on the central portion 38 and an outlet 80b at the circumferential narrowing 36. The position of the inlet 80a is such that it lies within the first chamber 6 in order to connect the first chamber 6 to the sixth chamber 16 when the slide 5a is moved into the first position and such that it lies in the second chamber 8 in order to connect it to the eighth chamber 21 when the slide 5a is moved into the second position.

[0053] Again differently from the slide 5, the slide 5a has, on the mid-lateral portion 40, a second passage 81 which, when the slide 5a is in the first position, connects the seventh chamber 17 to the fifth chamber 13.

[0054] In practice, in the second embodiment the slide 5a is preferably provided so as to be symmetrical with respect to the imaginary median plane 33a of the slide 5a.

[0055] The hydraulic circuit in which the pilot valve 1a is inserted, shown in Figures 10 to 12, is also identical to the hydraulic circuit shown in Figures 4 to 6. For this reason, the various elements of the circuit shown in Figures 10 to 12 have been designated by the same reference numerals as the elements of the circuit shown in Figures 4 to 6.

[0056] Operation of the device according to the invention in the second embodiment is as follows.

[0057] When the slide 5a is moved from the third position or idle position (Figures 9 and 12) to the first position (Figures 7 and 10), the first chamber 6 is connected to the second chamber 8, the sixth chamber 16 is connected to the eighth chamber 21, and the third chamber 9 is connected to the fifth chamber 13. The duct 80 connects the first chamber 6 to the sixth chamber 16, the duct 30 connects the third chamber 9 to the ninth chamber 22, and the passage 81 connects the seventh chamber 17 to the fifth chamber 13. In this operating condition, the branch P_1 of the hydraulic circuit is connected to the branch A of the user device, while the branch B of the user device is connected to the discharge branch T. The branch A of the user device is connected to the first adjustment duct 25, while the second branch B and the second adjustment duct 26 are connected to the discharge branch T.

[0058] Moreover, in this first position the pressure in

input to the pilot valve is transmitted, through the second internal duct 80, to the control duct 20 and assists the spring 60 in its action on the pressure compensator 2 in order to maintain or increase its aperture. Part of the flow in input to the pilot valve 1 is conveyed into the discharge branch T through the second passage 81, which connects the seventh chamber 17 to the fifth chamber 13, owing to the connection provided between the sixth chamber 16 and the seventh chamber 17. The extent of the flow conveyed to the discharge branch T depends on the position of the slide 5a owing to the particular configuration of the second passage 81.

[0059] In this first position, the signal LS is also transmitted, through switching or selection valves, to a flow/pressure regulator, as already described with reference to the first embodiment, in order to keep said flow/pressure regulator in the closure position, thus forcing the pump that feeds the pressurized branch to work at pressures which are higher than those actually required to actuate the user device.

[0060] By moving the slide 5a into the second position one obtains an operation which is similar to the one described with reference to the first embodiment, i.e., the pump operates with higher pressures for the supply of the branch B of the user device as well. Owing to this fact, both during the actuation of the branch A of the user device and during the actuation of the branch B of the user device the pump is forced to operate at pressures which are higher than those required to actuate the user device and accordingly higher operating stability is obtained.

[0061] It should be noted that both in the first embodiment and in the second embodiment the pressurized fluid drawn from the central chamber, through the internal duct 30 or 80, and is conveyed to the discharge, through the corresponding passage 31 or 81, allows to keep the chamber 16 and 17 at the same pressure and thus ensures perfect hydrostatic support of the slide 5 or 5a.

[0062] In practice it has been observed that the device according to the invention fully achieves the intended aim and objects, since by way of the fact that it forces the pump to operate at a pressure which is higher than the pressure actually required by the actuation of the user device, it achieves higher operating stability even if the user device requires reduced pressures and flow-rates in order to be actuated.

[0063] A further advantage of the device according to the invention is that it allows to use a pilot valve which can be derived very simply from conventional pilot valves, for example of the type disclosed in patent No. 1,281,708, simply by replacing the slide.

[0064] The device thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept; all the details may furthermore be replaced with other technically equivalent elements.

[0065] In practice, the materials employed, as well as

the dimensions, may be any according to requirements and to the state of the art.

[0066] The disclosures in Italian Patent Application No. MI99A002467, from which this application claims priority, are incorporated herein by reference.

[0067] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

15 Claims

1. A hydraulic control device, for the actuation of a hydraulic user device, with input pressure compensator, comprising a bidirectional pilot valve which can be actuated in order to connect one actuation branch of a user device to a pressurized branch of a hydraulic circuit and the other actuation branch of the user device to a discharge branch of the hydraulic circuit, and a pressure compensator, which is arranged on the pressurized branch of the hydraulic circuit that enters said pilot valve, said pilot valve comprising a valve body in which a substantially cylindrical seat is provided which slidingly accommodates a slide, said seat having, along its axial extension, larger-diameter regions which are alternated with smaller-diameter regions which are slidingly coupled to said slide; said larger-diameter regions forming in the valve body, around said slide, a plurality of chambers which comprise a first chamber in a substantially central position, which is connected to a first port which is connected to the pressurized branch of the hydraulic circuit; a second chamber and a third chamber being formed laterally on opposite sides with respect to said first chamber and being connected respectively to a second port which is connected to a user device actuation branch and to a third port which is connected to another user device actuation branch; a fourth chamber and a fifth chamber being formed laterally to said second chamber and said third chamber, on the opposite side with respect to said first chamber, and being connected respectively to a fourth port and a fifth port which are connected to the discharge branch of the hydraulic circuit; a sixth chamber and a seventh chamber being formed laterally to said fourth chamber and to said fifth chamber, on the opposite side with respect to said first chamber, and being connected respectively to a sixth port and a seventh port which are connected to a control duct which is connected to said pressure compensator for its actuation in contrast with the pressure along said pressurized branch which enters the pilot valve; said slide being movable on command into

three positions: a first position, in which it connects said first chamber to said second chamber and said third chamber to said fifth chamber; a second position, in which it connects said first chamber to said third chamber and said second chamber to said fourth chamber; and a third position, or idle position, in which it interrupts the connection of said first chamber to said second chamber and to said third chamber; characterized in that said sixth chamber is connected to said seventh chamber and in that said slide has at least one first internal duct which connects said first chamber to said sixth chamber or to said seventh chamber when the slide is in said first position or in said second position, said slide further having at least one first passage which connects said seventh chamber to said fifth chamber or said sixth chamber to said fourth chamber when the slide is in said first position or in said second position.

2. The device according to claim 1, characterized in that an eighth chamber and a ninth chamber are formed at said seat, in the valve body, laterally to said sixth chamber and said seventh chamber, on the opposite side with respect to said first chamber, and are respectively connected to an eighth port, which is connected to an adjustment duct, and to a ninth port, which is connected to another adjustment duct; said slide, in said first position, connecting said sixth chamber to said eighth chamber and, in said second position, connecting said seventh chamber to said ninth chamber.

3. The device according to claims 1 and 2, characterized in that said chambers are arranged symmetrically with respect to a median plane which is perpendicular to the axis of said seat and in that said slide has an active region which is substantially cylindrical and has mutually spaced circumferential narrowings and is designed to interact with said chambers.

4. The device according to one or more of the preceding claims, characterized in that said circumferential narrowings delimit, in said active region of the slide, a central portion, two mid-lateral portions, and two end-lateral portions of said slide; recesses being provided which extend from said mid-lateral portions to said central portions astride the narrowings located between said portions; said recesses connecting said second chamber to said first chamber and said third chamber to said fifth chamber when said slide is in the first position and connecting said first chamber to said third chamber and said second chamber to said fourth chamber when said slide is in the second position.

5. The device according to one or more of the preceding

claims, characterized in that said recesses are shaped like a cups which widens gradually toward the outer surface of said slide and also gradually widens from said mid-lateral portions and from said central portion toward the circumferential narrowings which they straddle.

6. The device according to one or more of the preceding claims, characterized in that said internal duct has an inlet on said central portion and an outlet on the circumferential narrowing located between one of said mid-lateral portions and the contiguous end-lateral portion.

7. The device according to one or more of the preceding claims, characterized in that said first passage is constituted by a choke formed in a mid-lateral portion of said slide.

8. The device according to one or more of the preceding claims, characterized in that said choke has a cross-section which gradually tapers toward said central portion of said slide.

9. The device according to one or more of the preceding claims, characterized in that said slide has a second internal duct which connects said second chamber to said sixth chamber or said fourth chamber to said eighth chamber when the slide is in said first position or in said second position.

10. The device according to one or more of the preceding claims, characterized in that said first internal duct of the slide lies in the portion of the slide located between said central portion and an axial end of the slide, said second internal duct being arranged in the portion of the slide that lies between said central portion and the other axial end of the slide.

11. The device according to one or more of the preceding claims, characterized in that said slide has:

- a first internal duct, which connects said first chamber to said sixth chamber when the slide is in said first position and connects said second chamber to said eighth chamber when the slide is in said second position;
- a first passage, which connects said seventh chamber to said fifth chamber when the slide is in said first position;
- a second internal duct, which connects said third chamber to said ninth chamber when the slide is in said first position and connects said first chamber to said seventh chamber when the slide is in said second position;
- a second passage, which connects said sixth chamber to said fourth chamber when the slide is in said second position.

12. The device according to one or more of the preceding claims, characterized in that said control duct is connected to a flow/pressure regulator which connects the pressurized branch to the discharge branch of the hydraulic circuit, in order to produce or increase its closure in contrast with the action applied by the pressure in said pressurized branch.

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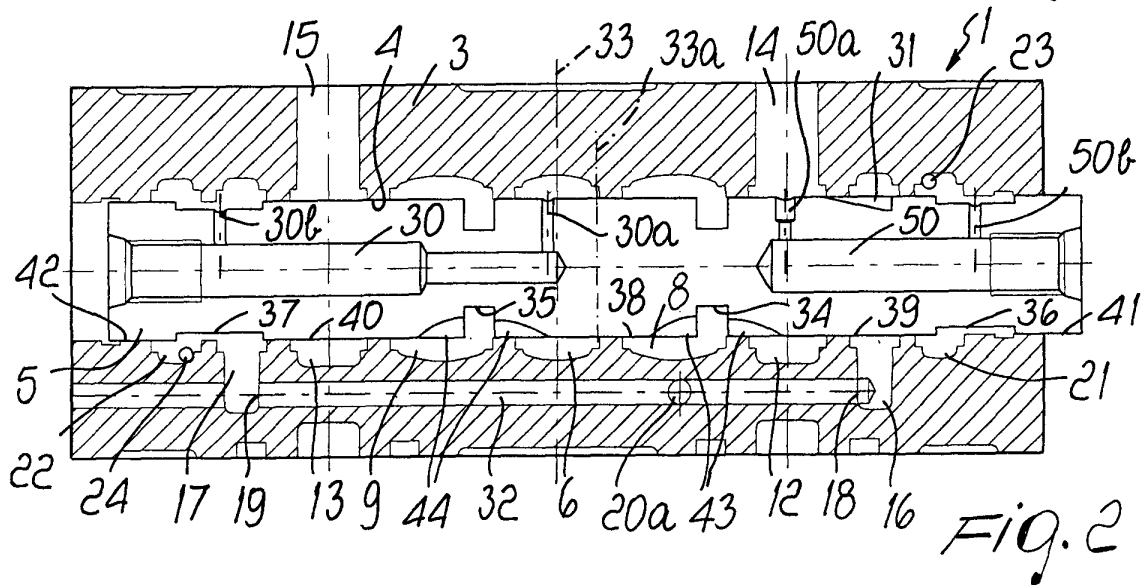
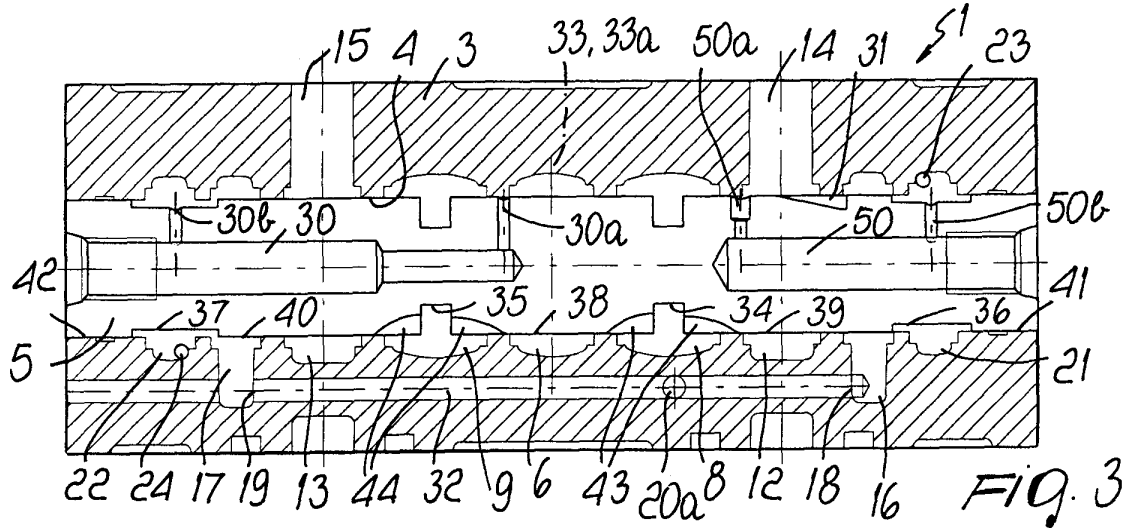
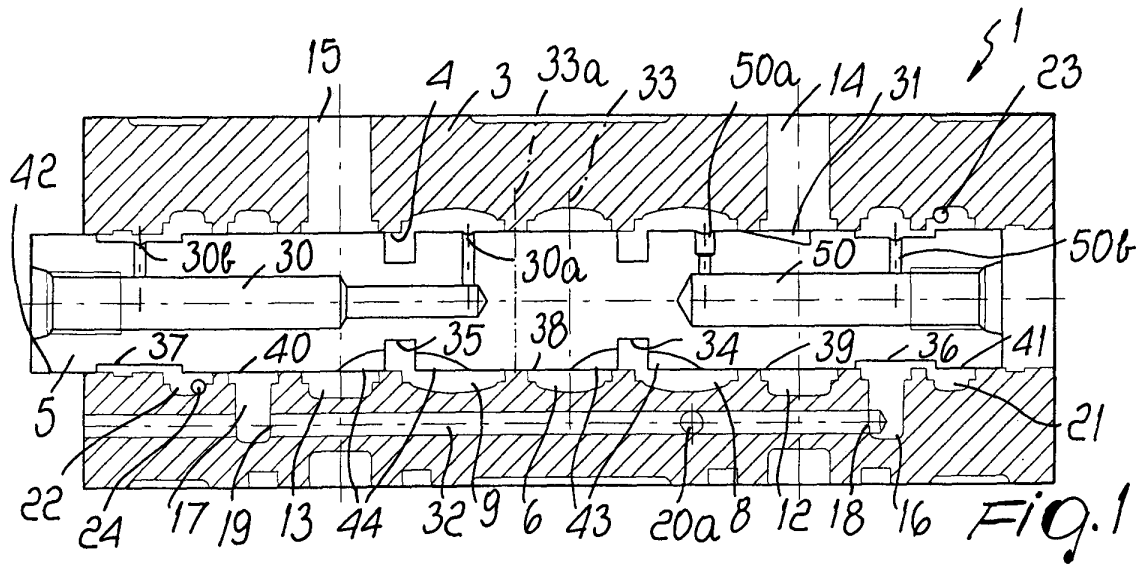
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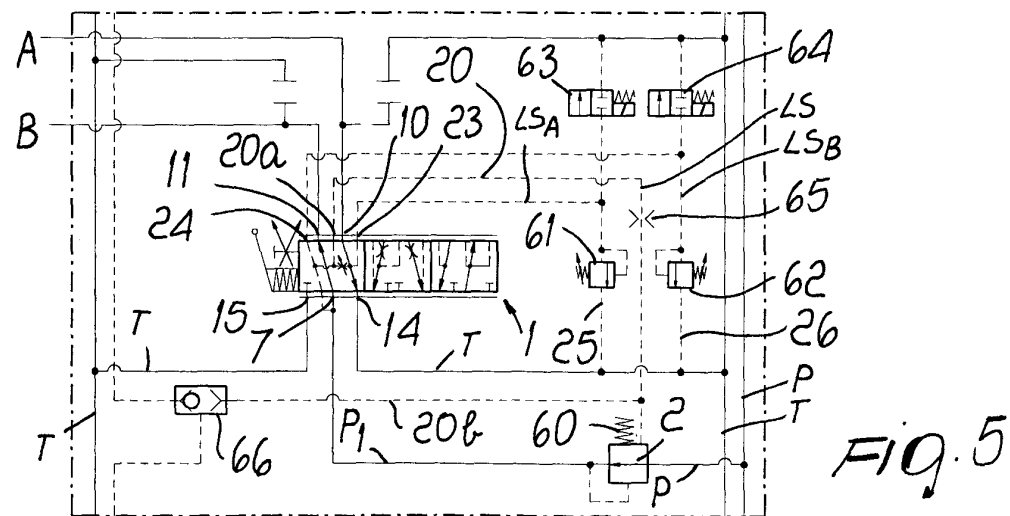
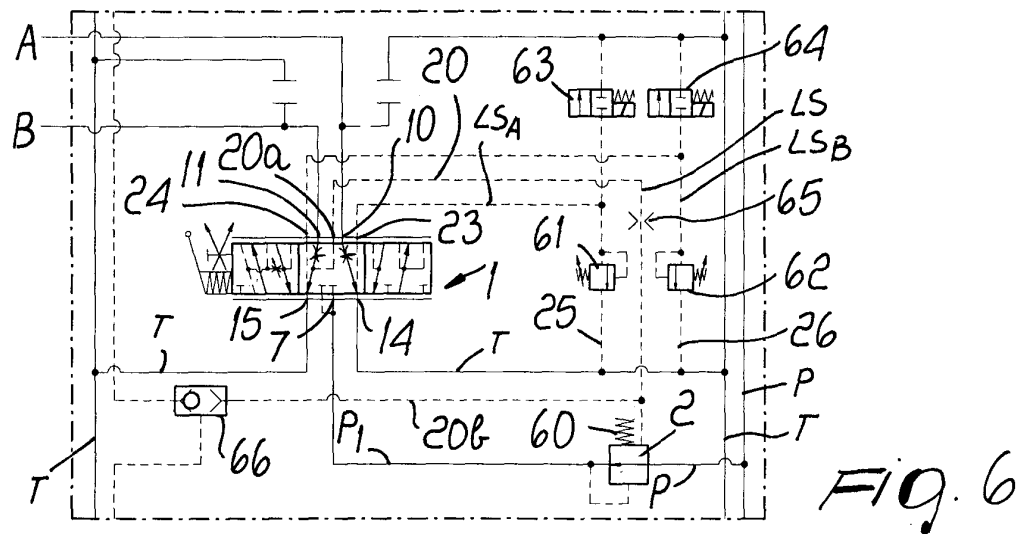
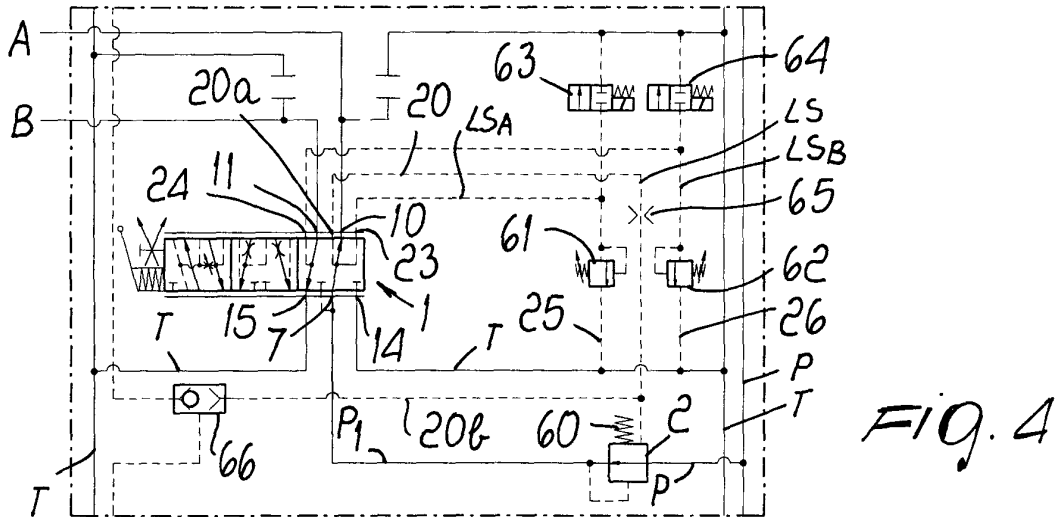
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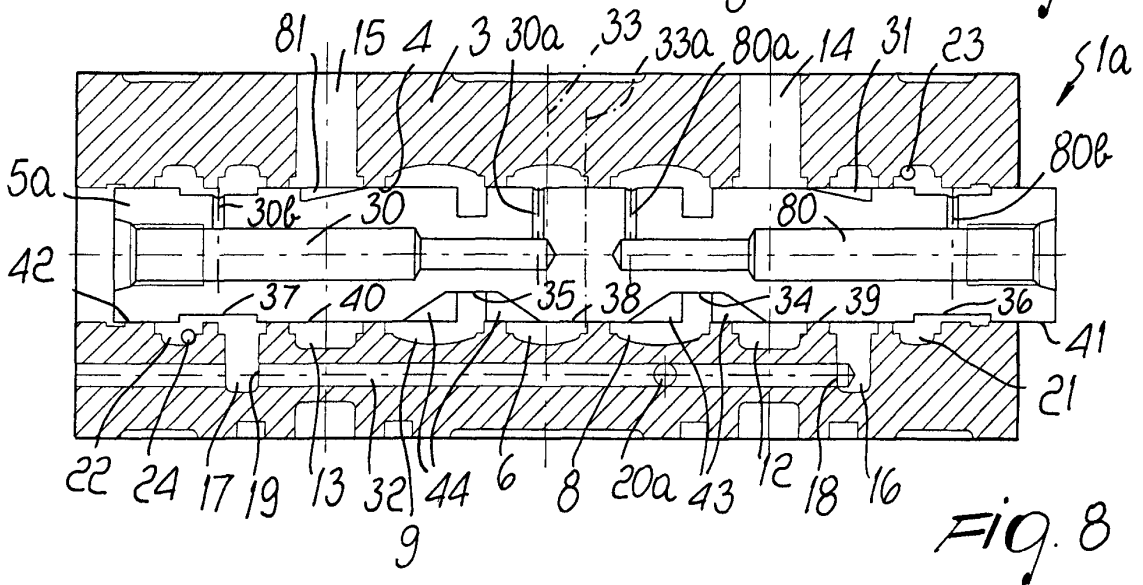
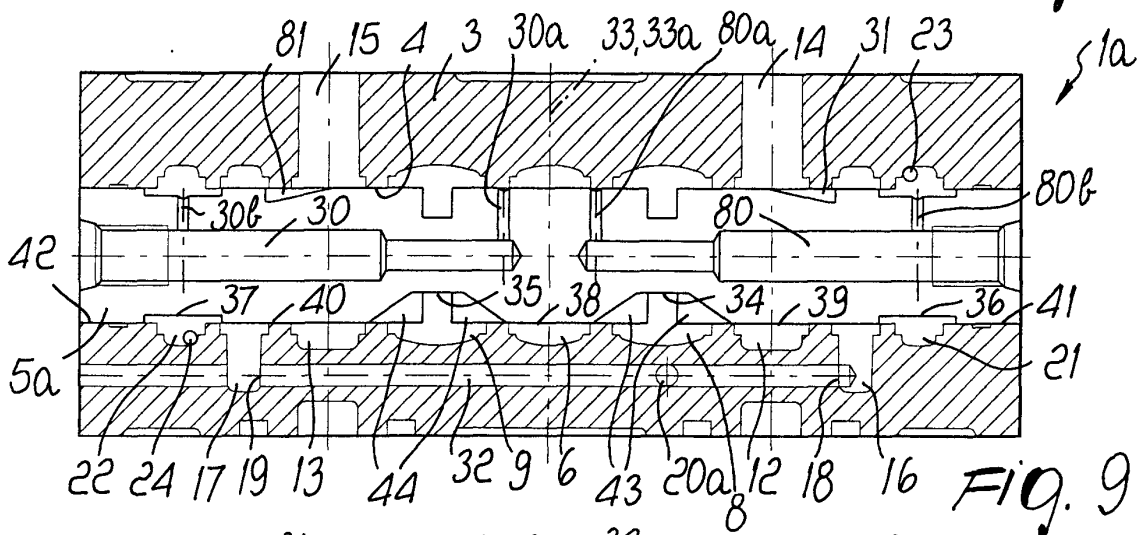
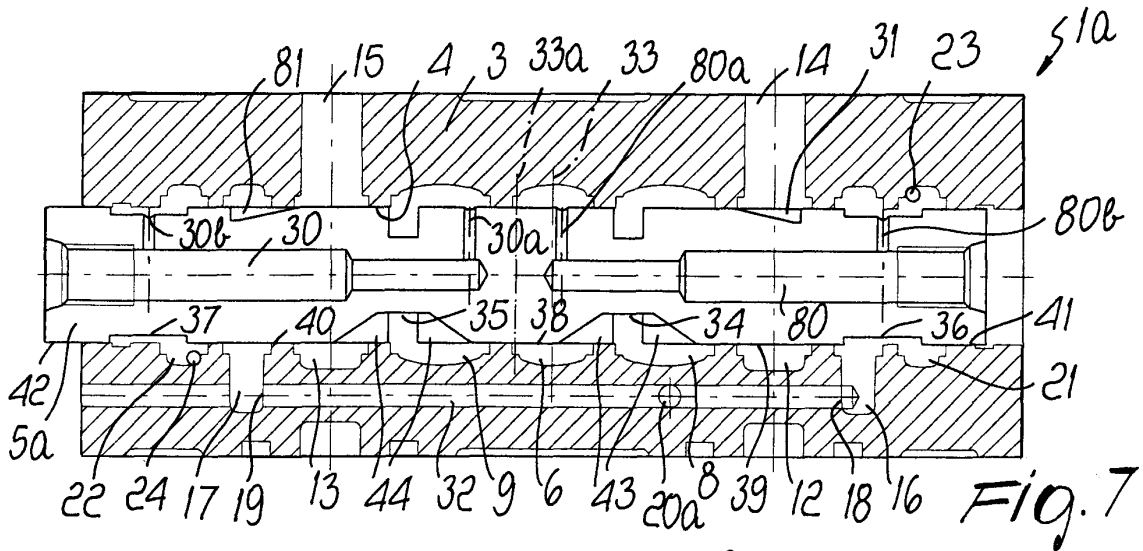
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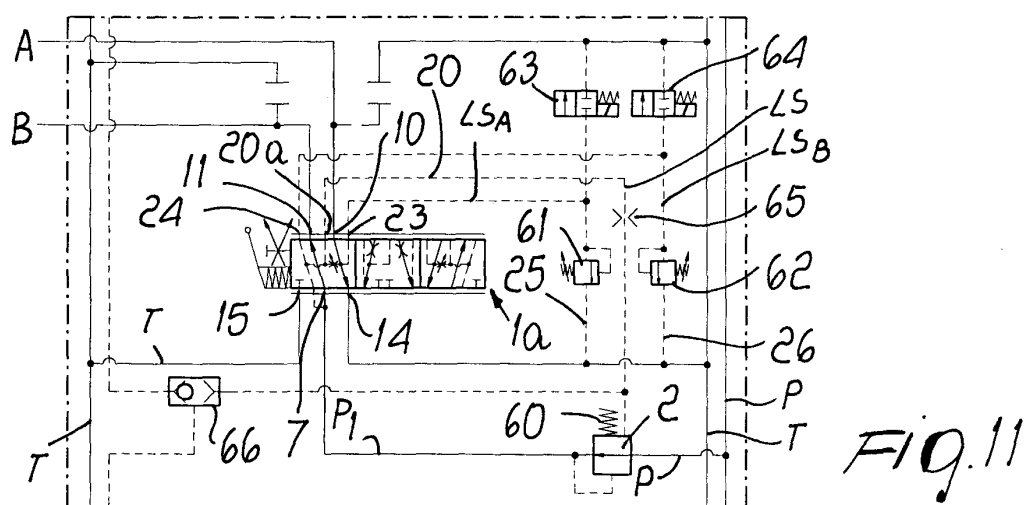
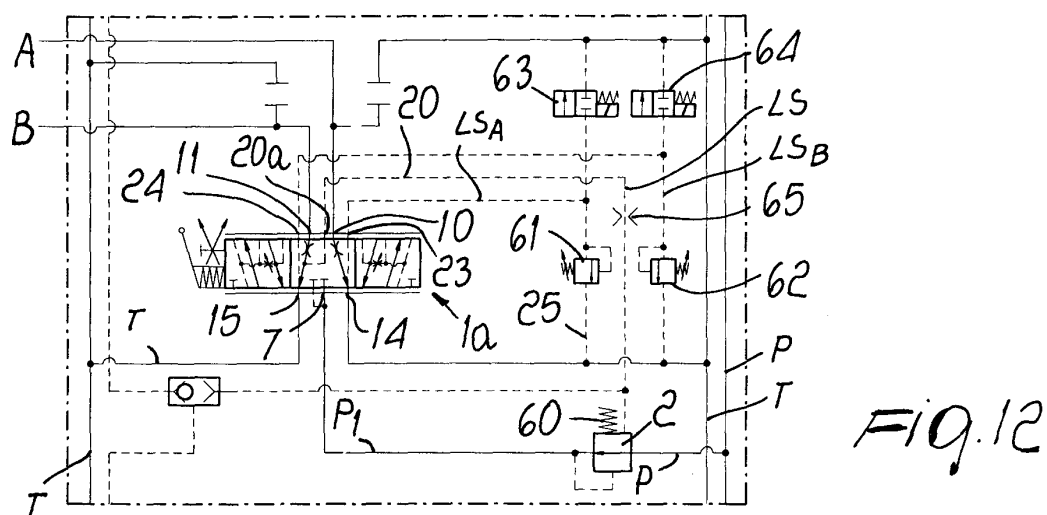
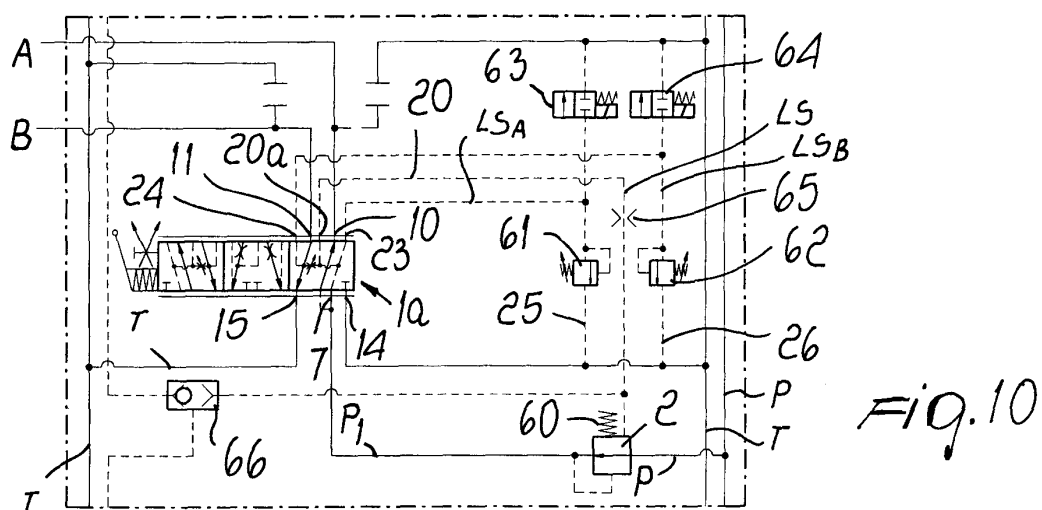
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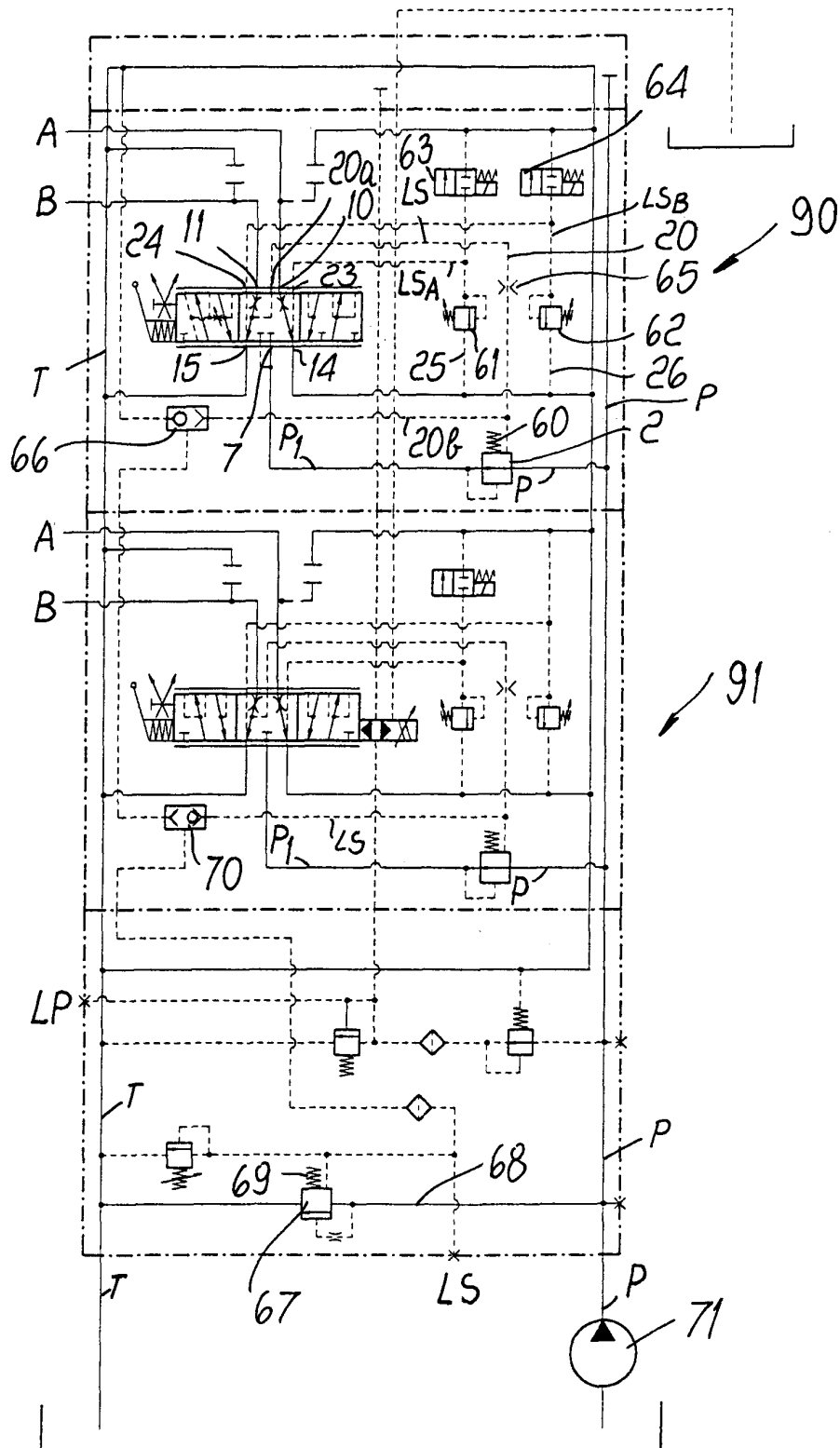


Fig. 13