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(54) Device for actuating a hydraulic user apparatus with an actuation speed that is independent of the resisting load affecting the hydraulic apparatus

(57) A hydraulic control device for the actuation of a hydraulic user apparatus with an actuation speed that is independent of the resisting load affecting the hydraulic user apparatus. The device comprises a double-acting pilot valve (1), which can be actuated so as to connect a user apparatus actuation branch (A, B) to a pressurized branch (P) of a hydraulic circuit and so as to connect the other user apparatus actuation branch (B, A) to a discharge branch (T) of the hydraulic circuit, and a pressure compensation unit (2), which is arranged on the pressurized branch (P) of the hydraulic circuit entering the pilot valve (1). The pilot valve (1) has: a first inlet (3) connected to the pressurized branch (P_1) of the hydraulic circuit; at least one second inlet (4a, 4b) connected to the discharge branch (T) of the hydraulic circuit; a first outlet (5) connected to a first user apparatus actuation branch (A, B); a second outlet (6) connected to the second user apparatus actuation branch (A, B); a first outlet port (7) connected to a first monitoring duct (8); a second outlet port (9) connected to a second monitoring duct (10); a third outlet port (11) connected to a control duct (12) which is connected to the pressure compensation unit (2) to actuate it in contrast with the pressure along the pressurized branch (P) of the hydraulic circuit. The pilot valve (1) has a slider (15) movable on command into three positions: a first position, wherein the slider connects the first inlet (3) to the first outlet (5), to the first port (7), and to the third port (11) and the second inlet (4b) to the second outlet (6) and to the second port (9); a second position, wherein it connects the first inlet (3) to the second outlet (6), to the second port (9), and to the third port (11) and the second inlet (4a) to the first outlet (5) and to the first port (7); and a third position, or idle position, wherein it closes the first inlet (3).

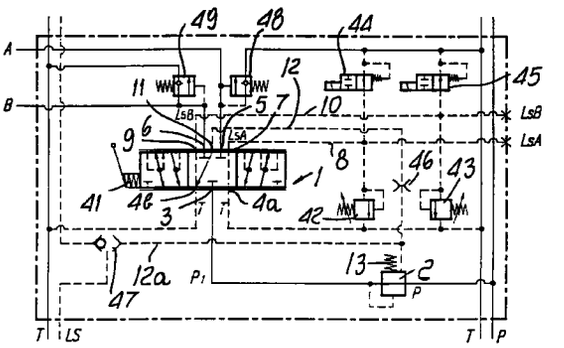

Fig. 8

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Description

The present invention relates to a hydraulic control device for actuating a hydraulic user apparatus with an actuation speed that is independent of the resisting load affecting the hydraulic user apparatus. More particularly, the device according to the present invention is meant to be used in hydraulic systems for the actuation of user apparatuses constituted by double-action fluid-actuated cylinders, or of hydraulic motors, or of user apparatuses with two actuation branches 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.

Conventional hydraulic circuits are generally supplied by a single pump of adequate capacity and are meant to actuate a plurality of user apparatuses which usually have different loads or require mutually different pressures for their actuation.

It should be noted that, generally, the various user apparatuses must be controlled fully independently; i.e., variations in the resisting load or in the actuation of a user apparatus must not affect the actuation of the other user apparatuses. Each user apparatus is usually controlled by a pilot valve or directional valve, which selectively connects the two hydraulic supply branches of the corresponding user apparatus to the pressurized branch of the main circuit or to the discharge branch, or closes the two supply branches of the user apparatus being considered.

In order to achieve correct operation of the various user apparatuses, preventing the flow delivered by the pump from being fed mainly towards the user apparatus with the lowest load, negatively affecting the user apparatuses with higher loads, a pressure compensation unit is arranged on the branch of the circuit connecting the pressurized branch, i.e., the delivery of the pump, to the pilot valve of each user apparatus. The pressure compensation unit has the purpose of maintaining a constant pressure difference 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 which forms across the valve gear or slider of the pilot valve.

The operating pressure that overcomes or brakes the load acts, together with a spring, so as to increase the opening of the compensation unit in contrast with the pressure acting on the feed branch of the pilot valve.

In practice, by actuating the pilot valve, the two feed branches of the user apparatus 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 apparatus connected to the pressurized branch is also connected, by means of said pilot valve, to a duct that enters the pressure compensation unit and wherethrough the operating pressure is transmitted to the pressure compensation unit.

The pressure transmitted along said duct from the user apparatus branch to the pressure compensation unit constitutes a hydraulic signal known as "load sensing" or LS, which accordingly drives the pressure compensation unit.

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

In some case it must also be possible to interrupt the actuation of the user apparatus being considered when two different maximum pressures are reached on the two actuation branches of the user apparatus.

In order to meet these requirements, specific devices have been provided; one thereof is disclosed in German patent DE-38.41.507. Said device comprises a double-acting three-position pilot valve, which respectively connects a user apparatus actuation branch to the pressurized branch of the hydraulic circuit whilst it connects the other user apparatus actuation branch to the discharge, or vice versa, or simultaneously closes the two user apparatus feed branches when no actuation is required.

The device comprises also two different ducts for the LS signals, LS_A and LS_B respectively, which are connected by the same pilot valve to the user apparatus actuation branches A and B when the branches A and B are connected to the pressurized branch of the hydraulic circuit. The duct LS_A or LS_B that is not used, i.e., the one corresponding to the user apparatus actuation branch connected to the discharge, is closed by the gear or slider of the pilot valve.

A maximum-pressure valve is arranged along each duct LS_A and LS_B; the two maximum-pressure valves provided have maximum pressures for intervention different from each other. The two ducts LS_A and LS_B, downstream of the maximum-pressure valves, merge into a single duct entering the pressure compensation unit, on the spring side, in order to drive it. The two ducts LS_A and LS_B are merged by means of a switching or selector valve, which connects the duct LS_A or LS_B that is at the highest pressure to the duct leading into the pressure compensation unit, whilst the other duct LS_B or LS_A is closed.

A device of the type described in patent DE-38.41.507 allows to stop the actuation of the user apparatus when two different maximum pressures are reached on the two branches A or B for the actuation of the user apparatus, but it entails drawbacks.

Unwanted leakages of liquid from the duct LS_A or LS_B under pressure towards the closed duct LS_B or LS_A can in fact occur during operation in the switching or selector valve. These leakages increase the pressure along the closed duct LS_B or LS_A until said pressure reaches the same value as the pressure in the pressu-

rized duct LS_A or LS_B. When this occurs, the switching valve cannot operate correctly, and if along the unused or closed duct LS a maximum-pressure valve is provided that is set to a lower pressure than the maximum-pressure valve arranged on the duct LS being used, the two ducts LS are connected to the discharge by the opening of said maximum-pressure valve, causing an unwanted halting of the actuation of the user apparatus.

In order to obviate this drawback, in said patent DE-38.41.507 the unused LS duct is connected to the discharge by means of single-acting valves, one for each LS duct, which are located in the control rod of the pilot valve. However, this solution entails complexity in the execution of the pilot valve and forces to diversify the production of the pilot valve depending on whether one operates with a single maximum-pressure valve on the LS ducts or with two maximum-pressure valves.

Moreover, with devices of this type, in applications entailing a negative action on the load of the user apparatus being considered, such as for example during the lowering of the load in lifting machines, if the user apparatus is controlled by load descent control valves, pulsating and highly unstable pressures may occur in the LS duct being used, causing the continuous switching of the position of the switching valve located at the merging point of the two ducts LS. This affects the pressure compensation unit, which amplifies the pulsating effect, causing oscillations of the load during descent and severe instabilities in the structure of the machine as a whole.

The aim of the present invention is to solve the above described problems by providing a hydraulic control device for the actuation of a user apparatus with a speed that is independent of variations in the resisting load which, even when it must be possible to stop the load when different maximum pressures are reached on the two user apparatus actuation branches, is free from instability problems, i.e., is not affected by pressure pulses or instabilities.

Within the scope of this aim, an object of the present invention is to provide a device that can use a same pilot valve for different system configurations, such as to fully meet the most disparate operating requirements.

Another object of the invention is to provide a control device with a pilot valve providing extremely easy and precise actuation.

Another object of the invention is to provide a device wherein the pilot valve is structurally simple and easy to access during maintenance.

This aim, these objects, and others which will become apparent hereinafter are achieved by a hydraulic control device for the actuation of a hydraulic user apparatus with an actuation speed that is independent of the resisting load affecting said hydraulic user apparatus, comprising a double-acting pilot valve that can be actuated so as to connect a user apparatus actuation branch to a pressurized branch of a hydraulic circuit and the other user apparatus actuation branch to a discharge branch of the hydraulic circuit and a pressure compensation unit arranged on the pressurized branch of the hydraulic circuit entering said pilot valve, characterized in that said pilot valve has: a first inlet connected to the pressurized branch of the hydraulic circuit; at least one second inlet connected to the discharge branch of the hydraulic circuit; a first outlet connected to a first user apparatus actuation branch; a second outlet connected to the second user apparatus actuation branch; a first outlet port connected to a first monitoring duct; a second outlet port connected to a second monitoring duct; a third outlet port connected to a control duct which is connected to said pressure compensation unit to actuate it in contrast with the pressure along said pressurized branch entering the pilot valve, said pilot valve having a slider movable on command into three positions: a first position, wherein said slider connects the first inlet to said first outlet, to said first outlet port, and to said third outlet port and the second inlet to said second outlet and to said second outlet port; a second position, wherein said slider connects said first inlet to said second outlet, to said second outlet port, and to said third outlet port and said second inlet to said first outlet and to said outlet first port; and a third position, or idle position, wherein said slider closes said first inlet.

Further characteristics and advantages of the invention will become apparent from the following description of some 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:

figure 1 is a sectional view of the device according to the present invention, taken along a plane that passes through the axis of the pilot valve slider;
figure 2 is a lateral elevation view of the pilot valve slider;
figure 3 is an enlarged-scale sectional view of a detail of the device related to the pilot valve, taken along a different plane than the sectional view of figure 1, with the slider in the first position;
figure 4 is a view of the same detail as in figure 3, with the slider in the second position;
figure 5 is a view of the same detail as in figures 3 and 4, with the slider in the third position;
figure 6 is a schematic view of the device in a first embodiment, with the slider of the pilot valve in the first position;
figure 7 is a schematic view of the device in the embodiment shown in figure 6, with the slider of the pilot valve in the second position;
figure 8 is a schematic view of the device in the embodiment shown in figures 6 and 7, with the slider of the pilot valve in the third position;
figure 9 is a schematic view of the device in a second embodiment of the present invention;
figure 10 is a schematic view of the device in a third embodiment of the present invention;
figure 11 is a schematic view of the device in a

fourth embodiment of the present invention;

figure 12 is a schematic view of the device in a fifth embodiment of the present invention;

figure 13 is a schematic view of the device in a sixth embodiment of the present invention;

figure 14 is a schematic view of the device in a seventh embodiment, with the slider of the pilot valve in the first position;

figure 15 is a view of the device in the embodiment shown in figure 14, with the slider of the pilot valve in the second position;

figure 16 is a view of the device in the embodiment shown in figures 14 and 15, with the slider of the pilot valve in the third position.

With reference to figures 1 to 8, the device according to the invention comprises a double-acting pilot valve, generally designated by the reference numeral 1, which can be actuated so as to connect an actuation branch A or B of a hydraulic user apparatus to a pressurized branch P of a hydraulic circuit and the other actuation branch B or A of the user apparatus to a discharge branch T of the hydraulic circuit.

The device comprises also, in a per se known manner, a pressure compensation unit 2 arranged along the pressurized branch of the hydraulic circuit entering the pilot valve 1. The portion of the pressurized branch running from the pressure compensation unit 2 to the pilot valve 1 has been designated by P_1.

According to the invention, the pilot valve 1 has: a first inlet 3 connected to the pressurized branch P_1; at least one second inlet 4a and 4b (two second inlets in the illustrated case) connected to the discharge branch T of the hydraulic circuit; a first outlet 5 connected to the first branch A for the actuation of the user apparatus; a second outlet 6 connected to the second branch B of the user apparatus to be actuated; a first outlet port 7 connected to a first monitoring duct 8 (LS_A); a second outlet port 9 connected to a second monitoring duct 10 (LS_B); and a third outlet port 11 connected to a control duct 12 that enters the pressure compensation unit 2 on the side of the spring 13, so that the pressure of the liquid transmitted along the control duct 12 acts, together with the force of the spring 13, on the moving part 14 of the pressure compensation unit in contrast with the action applied by the pressure of the liquid along the branch P_1, which acts on the moving part 14 of the pressure compensation unit on the opposite side.

The pilot valve 1 has a slider 15 that can move on command into three positions: a first position, wherein it connects the first inlet 3 to the first outlet 5, to the first port 7, and to the third port 11 whilst it connects the second inlet 4b to the second outlet 6 and to the second port 9; a second position, wherein it connects the first inlet 3 to the second outlet 6, to the second port 9, and to the third port 11 whilst it connects the second inlet 4a to the first outlet 5 and to the first port 7; and a third position, or idle position, wherein it closes the first inlet 3, the first outlet 5, and the second outlet 6.

It should be noted that in the third position the slider 15 conveniently connects the ports 7 and 9 to the second inlets 4a and 4b, i.e., it connects the monitoring ducts 8 and 10 to the discharge branch T of the hydraulic circuit.

The pilot valve 1, as shown in particular in figures 1 to 5, comprises a body 16 wherein a substantially cylindrical seat 17 is provided which accommodates the slider 15 so that it can slide axially; the slider is also substantially cylindrical and has narrower regions spaced one from the other.

A first chamber 18 is formed in the body 16 at a median region of the seat 17 and is connected to the first inlet 3. A second chamber 19 and a third chamber 20 are formed laterally to the first chamber 18, and on opposite sides with respect to it, in the body 16 and again at the seat 17; chambers 19 and 20 are connected to the first outlet 5 and to the second outlet 6 respectively.

A fourth chamber 21 and a fifth chamber 22 are formed laterally to the second chamber 19 and to the third chamber 20, on the opposite side with respect to the first chamber 18, and are respectively connected to the inlet 4a and to the inlet 4b.

A sixth chamber 23 and a seventh chamber 24 are formed laterally to the fourth chamber 21 and to the fifth chamber 22, on the opposite side with respect to the first chamber 18, and are connected to the third port 11.

An eighth chamber 25 and a ninth chamber 26 are also formed laterally to the sixth chamber 23 and to the seventh chamber 24, on the opposite side with respect to the first chamber 18, and are connected to the first port 7 and to the second port 9 respectively.

The chambers 18-26 are delimited by the slider 15 towards the axis of the seat 17.

As shown in figures 3 to 5, the sixth chamber 23 and the seventh chamber 24 are connected one to the other by a channel 27 which is formed in the body 16 and is connected to the third port 11.

The slider 15, as mentioned, has a substantially cylindrical shape with four circumferential narrower regions 28, 29, 30, and 31, which divide the active region of the slider 15, i.e., the region located in the seat 17, into a central portion 32, two middle lateral portions 33 and 34, and two end lateral portions 35 and 36.

The various portions of the slider 15 are sized and arranged so that when the slider 15 is in the first position, shown in figure 3, the middle lateral portion 33 closes the fourth chamber 21 whilst the other middle lateral portion 34 closes the seventh chamber 24; when the slider 15 is in the second position, shown in figure 4, the middle lateral portion 34 closes the fifth chamber 22, whilst the middle lateral portion 33 closes the sixth chamber 23; when the slider 15 is in the third position, shown in figure 5, the central portion 32 closes the first chamber 18, whilst the two middle lateral portions 33 and 34 close the second chamber 19 and the third chamber 20.

The end lateral portions 35 and 36 provide the

hydraulic tightness of the seat 17 at its axial ends.

The slider 15 has also recesses 37 that are located astride the narrower regions 28 and 29, affecting the central portion 32 and the two middle lateral portions 33 and 34. Said recesses 37 are cusp-shaped and widen away from the axis of the slider 15, from the middle lateral portions 33 and 34, and from the central portion 32 towards the narrower regions 28 and 29.

The recesses 37 connect the second chamber 19 to the first chamber 18 and the third chamber 20 to the fifth chamber 22 when the slider 15 is in the first position (figure 3) and connect the first chamber 18 to the third chamber 20 and the second chamber 19 to the fourth chamber 21 when the slider 15 is in the second position (figure 4). When the slider 15 is in the third position (figure 5), the recesses 37 provide no connection.

A first passage 38 and a second passage 39 are formed inside the slider 15, on opposite sides with respect to the central portion 32.

The first passage 38 has at least one opening 38a at the narrower region 30 and at least one opening 38b in a region of the middle lateral portion 33 of the slider 15.

The second passage 39 has at least one opening 39a at the narrower region 31 and at least one opening 39b in a region of the middle lateral portion 34 of the slider 15.

The openings 38a, 38b and 39a, 39b are spaced from each other so that when the slider 15 is in the first position (figure 3) the first passage 38 connects the second chamber 19 to the sixth chamber 23 whilst the second passage 39 connects the fifth chamber 22 to the ninth chamber 26 and so that when the slider 15 is in the second position (figure 4) the first passage 38 connects the eighth chamber 25 to the fourth chamber 21 whilst the second passage 39 connects the third chamber 20 to the seventh chamber 24. When the slider 15 is in the third position (figure 5), the first passage 38 connects the fourth chamber 21 to the eighth chamber 25 whilst the second passage 39 connects the fifth chamber 22 to the ninth chamber 26.

The narrower regions 28-31, too, are meant to provide connections in the various positions of the slider 15. When the slider 15 is in the first position (figure 3), the narrower region 30 connects the sixth chamber 23 to the eighth chamber 25; when the slider 15 is in the second position (figure 4), the narrower region 31 connects the seventh chamber 24 to the ninth chamber 26; when the slider 15 is in the third position (figure 5), the narrower region 30 connects the sixth chamber 23 to the eighth chamber 25 whilst the narrower region 31 connects the seventh chamber 24 to the ninth chamber 26.

The chambers 18-26 are arranged symmetrically with respect to a median plane lying at right angles to the axis of the seat 17, and the active region of the slider 15 is also symmetrical with respect to a median plane which is perpendicular to the axis of the slider 15, so that said slider 15 can be inserted in the seat 17 in one direction or in the opposite direction depending on the intended position of the actuation unit of the slider 15, which in the illustrated embodiment is constituted by a lever 40 whereby the slider 15 is moved along the axis of the seat 17 in contrast with the action of a return spring 41. The actuation unit of the slider 15 can anyway be constituted also by an automatic actuation device of a conventional type, which is not shown for the sake of simplicity.

The device according to the invention, provided with the pilot valve 1 described so far, can be completed by other components according to requirements.

Figures 6 to 8 illustrate a first embodiment of the device according to the invention, meant to be used when it must be possible to stop the actuation of the user apparatus during the pressurized feeding of the branch A and during the pressurized feeding of the branch B when the pressure in the branches A and B reaches a preset maximum value, with the possibility of differentiating the maximum allowable pressure along the branch A from the maximum allowable pressure along the branch B. The device shown in figures 6 to 8 allows also to stop the actuation of the user apparatus independently on the two branches A and B by means of an external control.

More particularly, with reference to figures 6 to 8, the first monitoring duct 8, wherealong the pressurized hydraulic signal LS_A is transmitted, is connected to the discharge branch T of the hydraulic circuit across a maximum-pressure valve 42, which connects the duct 8 to the discharge branch T when a pressure at least equal to the set pressure of the valve 42 occurs along the duct 8.

The second monitoring branch 10, wherealong the pressurized hydraulic signal LS_B is transmitted, is also connected to the discharge branch T of the hydraulic circuit by means of a maximum-pressure valve 43, which connects the duct 10 to the discharge branch T when a pressure at least equal to the set pressure of the valve 43 occurs along the duct 10.

Advantageously, each monitoring duct 8 and 10 has a branch which is connected to the discharge branch T by means of respective controllable electric valves 44 and 45. In normal operating conditions, the electric valves 44 and 45 are energized, i.e. closed, and therefore prevent the connection of the ducts 8 and 10 to the discharge branch T, and can be de-energized in order to provide this connection when conditions occur requiring an interruption in the actuation of the user apparatus during actuation on the branch A or on the branch B.

The circuit shown in figures 6 to 8 is completed by a choke 46 arranged along the control duct 12 and by a branch 12a of the control duct 12 that enters a switching or selector valve 47. The outlet of the switching valve 47 is connected to the pump so as to send to the pump an LS signal for driving said pump.

For the sake of completeness in description, it should be noted that antishock valves are provided, designated by the reference numerals 48 and 49, in the

device shown in figures 6 to 8.

The operation of the device in the embodiment shown in figures 6 to 8 is as follows.

When the slider 15 is shifted from the idle position (figures 5 and 8) to the first position (figures 3 and 6), the branch P_1 is connected to the branch A. It should be noted that when the slider 15 is in this position, the branch A and the branch P_1 are connected to the control duct 12 and to the first monitoring duct 8, wherealong the hydraulic signal LS_A is transmitted.

Simultaneously, the branch B and the second monitoring duct 10, wherealong the hydraulic signal LS_B is transmitted, are connected to the discharge branch T.

If the pressure along the duct 8, which is correlated to the pressure along the branch A, exceeds the set maximum pressure of the valve 42, said valve opens, connecting the duct 8 and, through said duct 8, the duct 12 to the discharge branch T, causing the closure of the pressure compensation unit 2 and therefore halting the actuation of the user apparatus along the branch A.

The same occurs if the electric valve 44 is de-energized and therefore opened.

When the slider 15 is moved from the idle position (figures 5 and 8) to the second position (figures 4 and 7), the branch P_1 is connected to the branch B, to the control duct 12, and to the second monitoring duct 10.

In this case, the operating pressure of the user apparatus along the branch B affects the actuation of the pressure compensation unit 2 on the side of the spring 13 and is transmitted simultaneously to the second monitoring duct 10.

Simultaneously, the branch A and the first monitoring duct 8 are connected to the discharge branch T.

If the pressure along the duct 10, which is correlated to the pressure along the branch B, exceeds the set maximum pressure of the valve 43, said valve opens, connecting the duct 10 and, through said duct, the duct 12 to the discharge branch T, causing the closure of the pressure compensation unit 2 and therefore halting the actuation of the user apparatus along the branch B.

The same occurs if the electric valve 45 is de-energized, i.e., opened.

It should be noted that the connection of the monitoring duct, which corresponds to the branch of the user apparatus that is not connected to the branch P_1, to the discharge branch T in the device according to the invention is performed directly across the pilot valve 1 used to provide the other connections, as described above for the actuation of the user apparatus.

The connection to the discharge of the monitoring duct corresponding to the user apparatus branch that is connected to the discharge, in addition to preventing any pulses, for example during the lowering of a load in lifting machines, and in addition to achieving correct operation of the pressure compensation unit 2, also achieves better hydraulic balancing of the slider 15, facilitating its actuation and improving its precision.

According to requirements, one or both of the maximum-pressure valves 42 and 43, as well as one or both of the electric valves 44 and 45, can be omitted.

For example, if it is not necessary to be able to connect the two monitoring ducts 8 and 10 to the discharge through electric valves, but one wishes to have still the possibility of controlling the actuation of the user apparatus across the two branches A and B with different maximum allowable pressures on the branches A and B by using two maximum-pressure valves 42 and 43, the device has the appearance shown schematically in figure 9.

If one wishes to control directly the actuation on the two branches A and B of the user apparatus by means of two electric valves 44 and 45 without using maximum-pressure valves, the device has the appearance shown schematically in figure 10.

It should be noted that the connection of the monitoring ducts 8 and 10, and therefore of the user apparatus branch connected to said ducts, to the discharge by means of the electric valves 44 or 45 instead of the maximum-pressure valves 42 or 43 is faster.

The embodiment illustrated in figure 11 shows a device that uses only the electric valve 44.

In this embodiment, the actuation of the user apparatus along the branch A is controlled by means of said electric valve 44, whilst the actuation of the user apparatus along the branch B is controlled by the maximum general set pressure of the system. Nonetheless, even in this case it is possible to differentiate the maximum allowable pressures on the two branches A and B of the user apparatus. Of course, a similar operation, with reversal of the type of control on the two branches A and B of the user apparatus, would be achieved with a device that used only the electric valve 45.

In the embodiment illustrated in figure 12, the device according to the invention has the electric valve 44 and the maximum-pressure valve 42, whilst the valve 43 and the electric valve 45 are not present with respect to the diagram of figures 6 to 8.

In this case, the actuation of the user apparatus along the branch A is controlled by the valve 42 and by the electric valve 44, whilst the actuation of the user apparatus along the branch B is controlled simply by means of the general maximum set pressure of the system, which is of course higher than the intervention pressure of the valve 42. Similar operation would be achieved by using only the valve 43 and the electric valve 45, with a reversed type of control between the branches A and B with respect to what has been described above with reference to figure 12.

Figure 13 illustrates another embodiment of the device according to the invention, wherein only the maximum-pressure valve 42 is provided on the first monitoring duct 8.

In this case, the actuation pressure along the branch A of the user apparatus is controlled by means of the valve 42, whilst the actuation along the branch B of the user apparatus depends on whether the general maximum allowable pressure of the hydraulic system,

which is obviously higher than the set pressure of the valve 42, is exceeded or not. Similar operation, with a reversed control mode between the two branches A and B, would occur by using only the maximum-pressure valve 43 on the second monitoring duct 10.

Figures 9 to 13 illustrate several embodiments of the device according to the invention, already preset to be completed by simply adding one or more valves or electric valves until the embodiment of the device illustrated in figures 6 to 8 is achieved; of course this presetting may also not be provided.

All the embodiments shown in the above described figures therefore allow control, as mentioned, of the two branches A and B of the user apparatus with two maximum allowable pressures different or diversifiable one from the other.

If this possibility is not required, but it is sufficient to simply be able to control the actuation of the user apparatus along the branches A and B according to a same maximum allowable pressure, it is possible to use a device of the type shown in figures 14 to 16.

In this embodiment, the two monitoring ducts 8 and 10 enter a switching or selector valve 51, wherefrom a combined monitoring duct 52 exits; said duct 52 is connected to the discharge branch T of the hydraulic system by means of a maximum-pressure valve 53 or by means of an electric valve 54, or also by means of both the maximum-pressure valve 53 and the electric valve 54, as shown.

The other parts of the device shown in figures 14 to 16 that substantially correspond to the parts of the device already described with reference to the previous embodiments have been designated by the same reference numerals.

In particular, the fact is stressed that in the embodiment shown in figures 14 to 16 the pilot valve is again constituted by the same pilot valve 1 described earlier.

The operation of the device shown in figures 14 to 16 is as follows.

When the pilot valve is shifted from the third position, or equilibrium position (figure 16), to the first position (figure 14), the branch A of the user apparatus is connected to the branch P_1, to the monitoring duct 8, and to the control duct 12. In this first position, the pilot valve 1 also connects the branch B and the second monitoring duct 10 to the discharge branch T of the system. In this manner, the pressure along the branch A of the user apparatus is transmitted along the control duct 12 to the pressure compensation unit 2, along the first monitoring duct 8, and to the combined monitoring duct 52 across the switching valve 51. If the pressure occurring along the duct 52, which is correlated to the pressure along the branch A, is higher than the set pressure of the maximum-pressure valve 53, the combined monitoring duct 52 and, through said duct, the duct 12 and the branch A of the user apparatus are connected to the discharge branch T of the system, halting the actuation of the user apparatus. The same occurs if the electric valve 54 is de-energized; the electric valve thus connects the combined monitoring duct 52 and therefore the duct 12 and the branch A of the user apparatus to the discharge branch T of the system.

If instead the slider of the pilot valve 1 is moved into the second position (figure 15), the branch B of the user apparatus, the second monitoring duct 10, and the control duct 12 are connected to the pressurized branch P_1, whilst the branch A and the first monitoring duct 8 are connected to the discharge branch T of the system. The pressure along the branch B is transmitted to the control duct 12, driving the pressure compensation unit 2, as already described, and to the combined monitoring duct 52 across the switching valve 51.

If the pressure occurring along the combined monitoring duct 52, which is correlated to the pressure in the branch B, is higher than the set pressure of the maximum-pressure valve 53, the combined monitoring duct 52 and, through said combined monitoring duct, the duct 12 and the branch B of the user apparatus are connected to the discharge branch T, halting the actuation of the user apparatus.

The same occurs if the electric valve 54 is de-energized.

In practice, it has been observed that the device according to the invention fully achieves the intended aim, since by virtue of the fact that the monitoring duct, i.e., the "load sensing" signal transmitted along it, which corresponds to the branch of the user apparatus connected to the discharge, is also connected to the discharge, said device effectively avoids instabilities even in the presence of pressure instabilities or pulsations and facilitates also the actuation of the pilot valve and makes it more precise.

A further advantage is that it is possible to use a same pilot valve for several types of application.

Another advantage is that the device has a pilot valve which is structurally simple, without the need to insert valve elements inside the slider of the pilot valve.

The device thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept; thus, for example, if required, the pilot valve 1 can be modified so that when the slider 15 is in the third position, the branches A and B, instead of being closed, are connected to the inlets 4a or 4b, i.e., to the discharge branch T of the circuit.

All the details may furthermore be replaced with other technically equivalent elements.

In practice, the materials employed, as well as the dimensions, may be any according to the requirements and the state of the art.

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 interpretation of each element identified by way of example by such reference signs.

Claims

1. A hydraulic control device for the actuation of a hydraulic user apparatus with an actuation speed that is independent of the resisting load affecting said hydraulic user apparatus, comprising a double-acting pilot valve that can be actuated so as to connect a user apparatus actuation branch to a pressurized branch of a hydraulic circuit and the other user apparatus actuation branch to a discharge branch of the hydraulic circuit and a pressure compensation unit arranged on the pressurized branch of the hydraulic circuit entering said pilot valve, characterized in that said pilot valve has: a first inlet connected to the pressurized branch of the hydraulic circuit; at least one second inlet connected to the discharge branch of the hydraulic circuit; a first outlet connected to a first user apparatus actuation branch; a second outlet connected to the second user apparatus actuation branch; a first outlet port connected to a first monitoring duct; a second outlet port connected to a second monitoring duct; a third outlet port connected to a control duct which is connected to said pressure compensation unit to actuate it in contrast with the pressure along said pressurized branch entering the pilot valve, said pilot valve having a slider movable on command into three positions: a first position, wherein said slider connects said first inlet to said first outlet, to said first outlet port, and to said third outlet port and said second inlet to said second outlet and to said second outlet port; a second position, wherein said slider connects said first inlet to said second outlet, to said second outlet port, and to said third outlet port and said second inlet to said first outlet and to said first outlet port; and a third position, or idle position, wherein said slider closes said first inlet.

2. A device according to claim 1, characterized in that at least one of said monitoring ducts is connected to the discharge branch of the hydraulic circuit by means of a maximum-pressure valve.

3. A device according to claims 1 and 2, characterized in that both of said monitoring ducts are connected to the discharge branch of the hydraulic circuit through respective maximum-pressure valves which have set maximum pressures different from each other.

4. A device according to claim 1, characterized in that at least one of said monitoring ducts is connected to the discharge branch of the hydraulic circuit through a controllable electric valve.

5. A device according to claims 1 and 4, characterized in that both of said monitoring ducts are connected to the discharge branch of the hydraulic circuit through respective controllable electric valves.

6. A device according to claim 1, characterized in that at least one of said monitoring ducts is connected to the discharge branch of the hydraulic circuit through a maximum-pressure valve and through a controllable electric valve.

7. A device according to claim 1, characterized in that each monitoring duct is connected to the discharge branch of the hydraulic circuit through a maximum-pressure valve and through a controllable electric valve.

8. A device according to claim 1, characterized in that said two monitoring ducts are connected to a combined monitoring duct through a switching or selector valve.

9. A device according to claim 8, characterized in that said combined monitoring duct is connected to the discharge branch of the hydraulic circuit through a maximum-pressure valve.

10. A device according to claim 8, characterized in that said combined monitoring duct is connected to the discharge branch of the hydraulic circuit through a controllable electric valve.

11. A device according to claim 1, characterized in that said combined monitoring duct is connected to the discharge branch of the hydraulic circuit through a maximum-pressure valve and through a controllable electric valve.

12. A device according to claim 1, characterized in that said pilot valve comprises a valve body wherein a substantially cylindrical seat is provided that slidingly accommodates said slider; a first chamber being formed in the valve body at said seat in a substantially central position and being connected to said first inlet; a second chamber and a third chamber being formed laterally, on opposite sides with respect to said first chamber, and being connected to said first outlet and to said second outlet respectively; a fourth chamber and a fifth chamber being formed laterally to said second and third chambers, on the opposite side with respect to said first chamber, and being connected to said second inlet; a sixth chamber and a seventh chamber being formed laterally to said fourth and fifth chambers, on the opposite side with respect to said first chamber, and being connected to said third port; an eighth chamber and a ninth chamber being formed laterally to said sixth and seventh chambers, on the opposite side with respect to said first chamber, and being connected to said first port and to said second port respectively, said chambers being delimited by said slider towards the axis of said seat.

13. A device according to claim 12, characterized in

that said chambers are arranged symmetrically with respect to a median plane that is perpendicular to the axis of said seat and in that said slider has a substantially cylindrical active region, provided with mutually spaced circumferential narrower regions, which is meant to interact with said chambers, said active region having a symmetrical shape with respect to a median plane that is perpendicular to the axis of the slider for the insertion of said slider in said seat in one direction or in the opposite one.

14. A device according to claim 13, characterized in that said narrower regions delimit, in said active region of the slider, a central portion, two middle lateral portions, and two end lateral portions of said slider; one of said middle lateral portions closing said fourth chamber, whilst the other middle lateral portion closes said seventh chamber, when said slider is in said first position; one of said middle lateral portions closing said fifth chamber, whilst the other middle lateral portion closes said sixth chamber, when said slider is in said second position; said central portion and said two middle lateral portions closing said first chamber, said second chamber, and said third chamber when said slider is in said third position.

15. A device according to claim 12, characterized in that said sixth chamber and said seventh chamber are connected to each other by means of a channel formed in the body of the pilot valve.

16. A device according to claim 14, characterized in that it comprises recesses extending from said middle-lateral portions to said central portion astride the narrower regions arranged between said portions, said recesses connecting said second chamber to said first chamber and said third chamber to said fifth chamber when said slider is in the first position and connecting said first chamber to said third chamber and said second chamber to said fourth chamber when said slider is in the second position.

17. A device according to claim 16, characterized in that said recesses are cusp-shaped and widen gradually towards the outer surface of said slider and also widen gradually from said middle-lateral portions and from said central portion towards the narrower regions of the slider, astride which they extend.

18. A device according to claim 17, characterized in that it comprises, inside said slider, a first passage and a second passage, which are arranged on opposite sides with respect to a median region of the slider, each one of said passages having at least two openings located respectively at the narrower region that divides one of said end lateral portions from the contiguous middle lateral portion and at a region of said middle lateral portions; said first passage connecting said second chamber to said sixth chamber, whilst said second passage connects said fifth chamber to said ninth chamber, when said slider is in said first position; said first passage connecting said fourth chamber to said eighth chamber, whilst said second passage connects said third chamber to said seventh chamber, when said slider is in said second position; said first passage connecting said fourth chamber to said eighth chamber, whilst said second passage connects said fifth chamber to said ninth chamber, when said slider is in said third position.

19. A device according to claim 14, characterized in that said narrower regions that separate said middle lateral portions from said end lateral portions connect said sixth chamber to said eighth chamber when said slider is in said first position, connect said seventh chamber to said ninth chamber when said slider is in said second position, and connect said sixth chamber to said eighth chamber and said seventh chamber to said ninth chamber when said slider is in said third position.

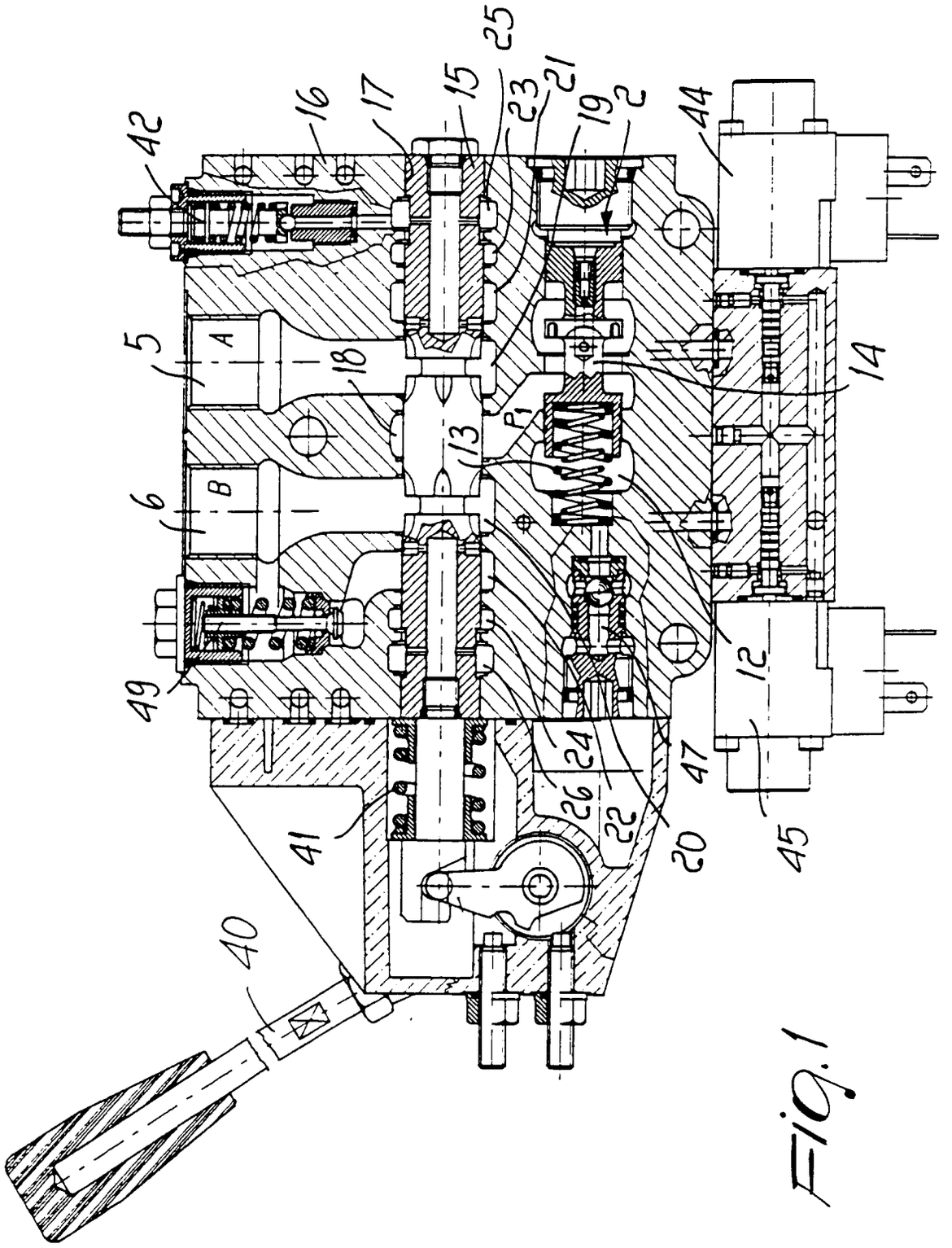
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Fig.1

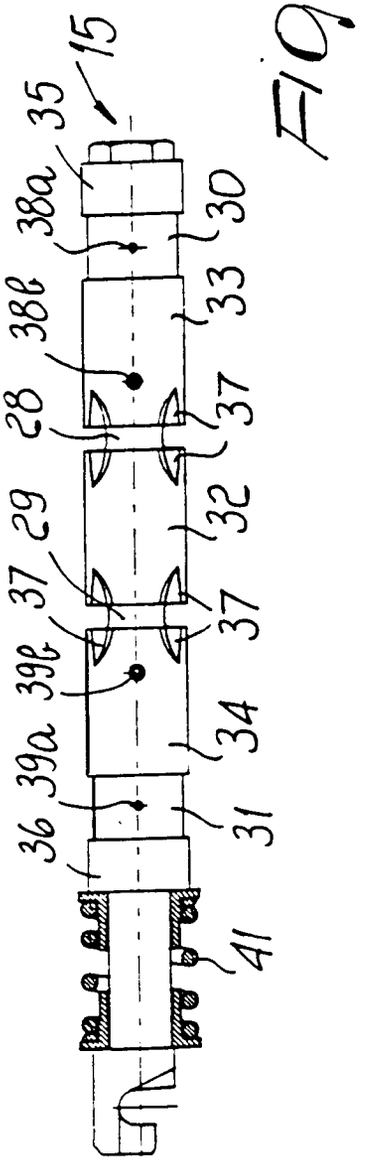
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Fig. 2

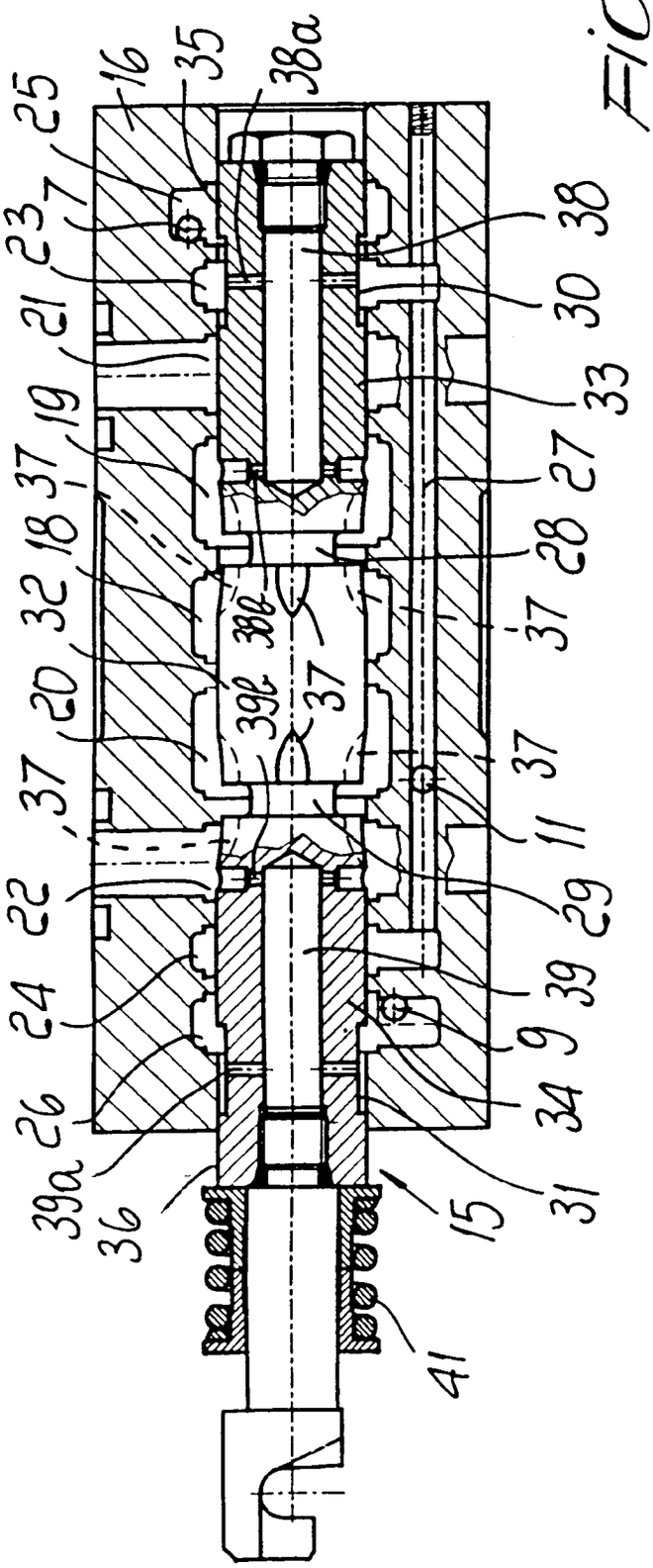
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Fig. 3

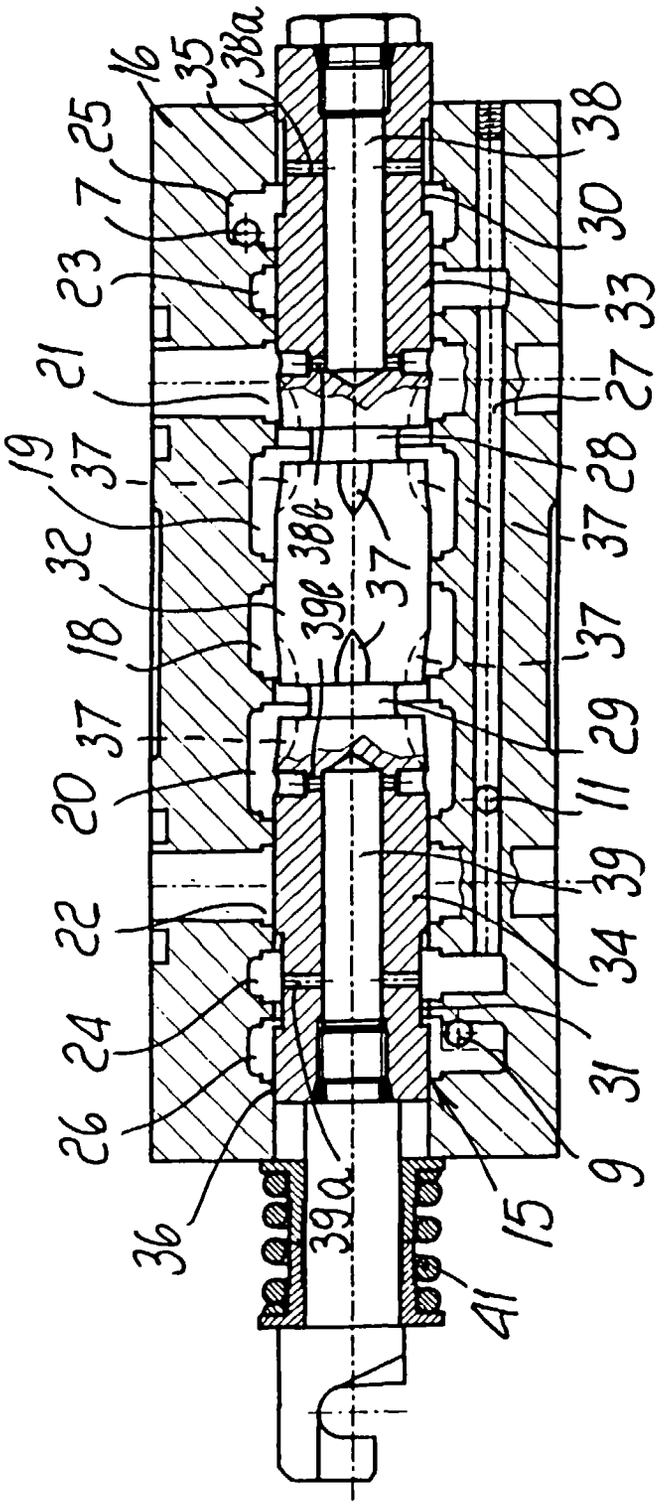
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Fig. 4

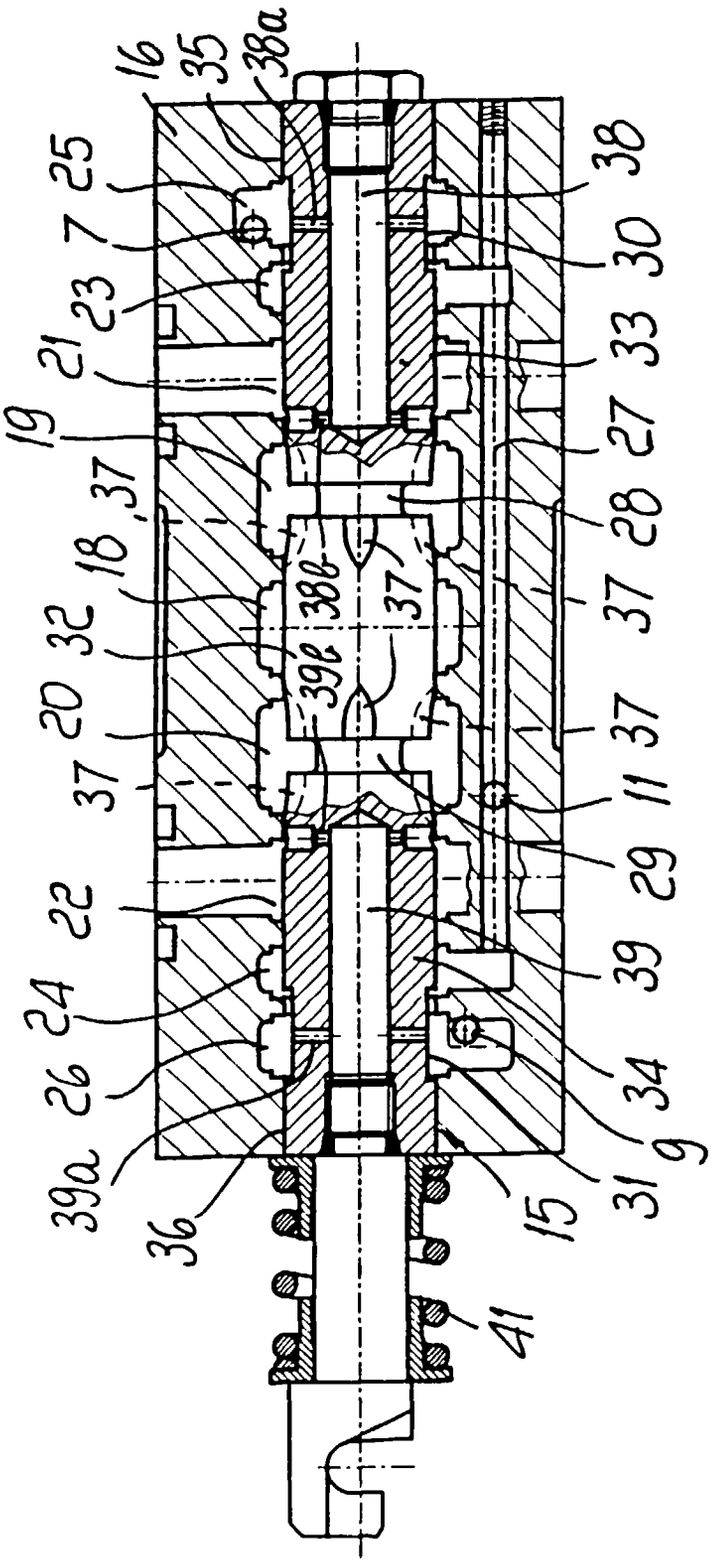
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Fig. 5

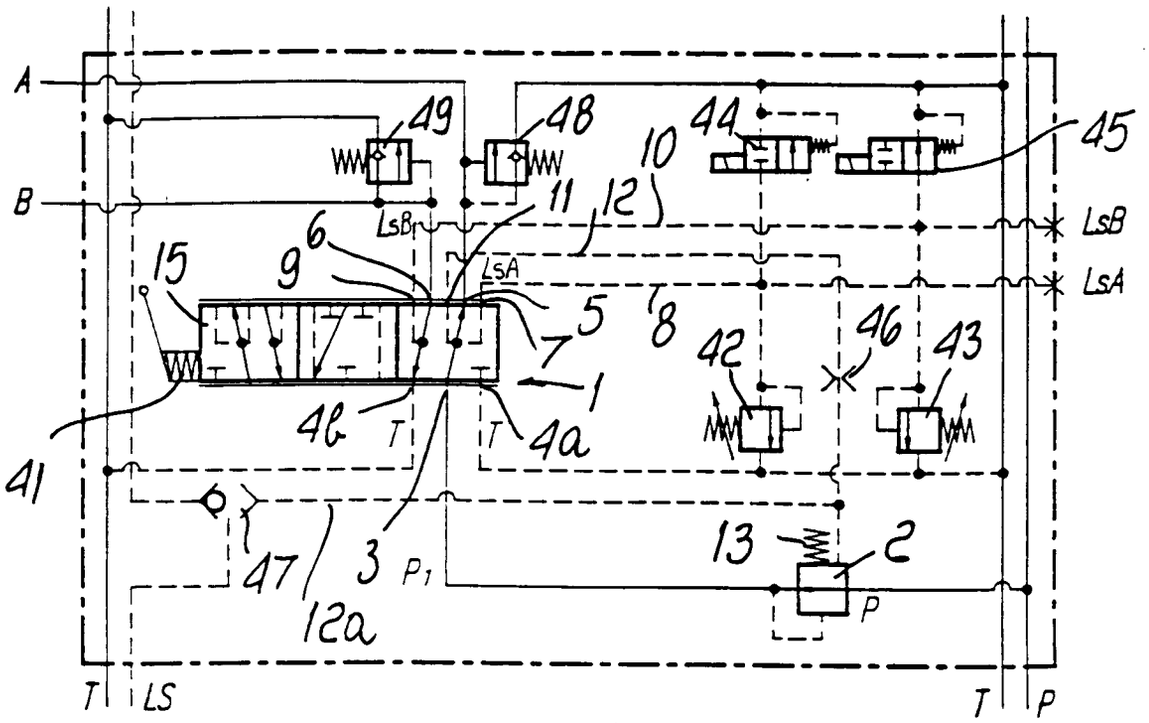
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FIG. 6

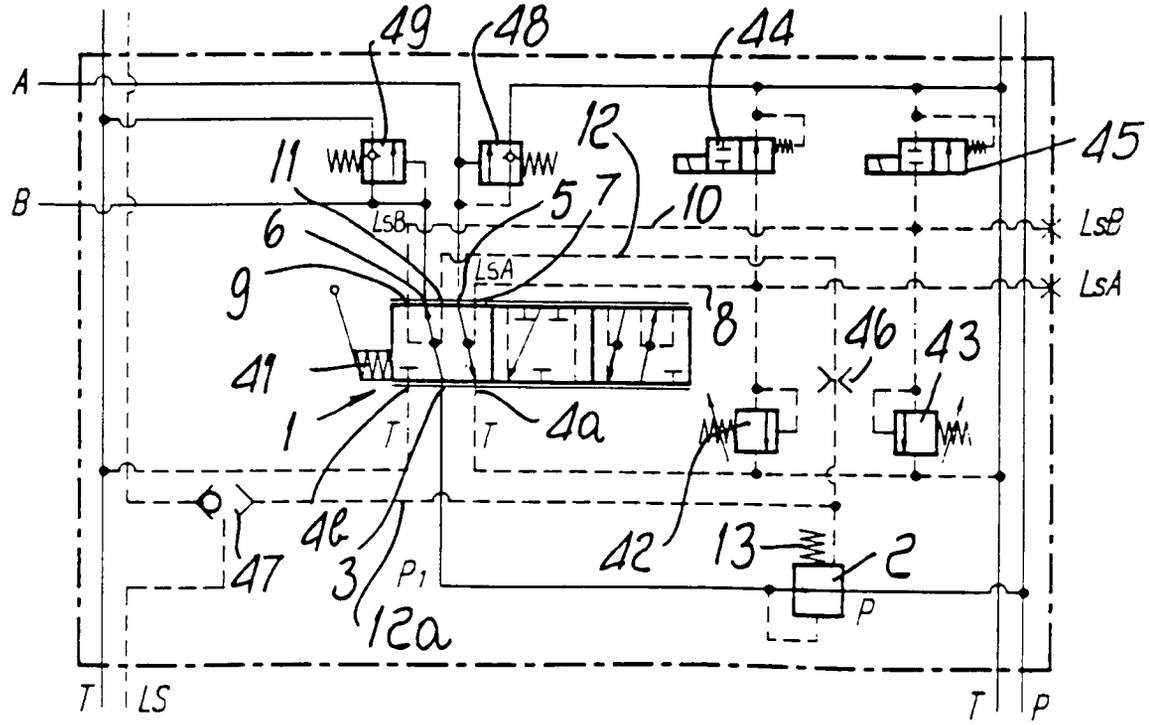
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FIG. 7

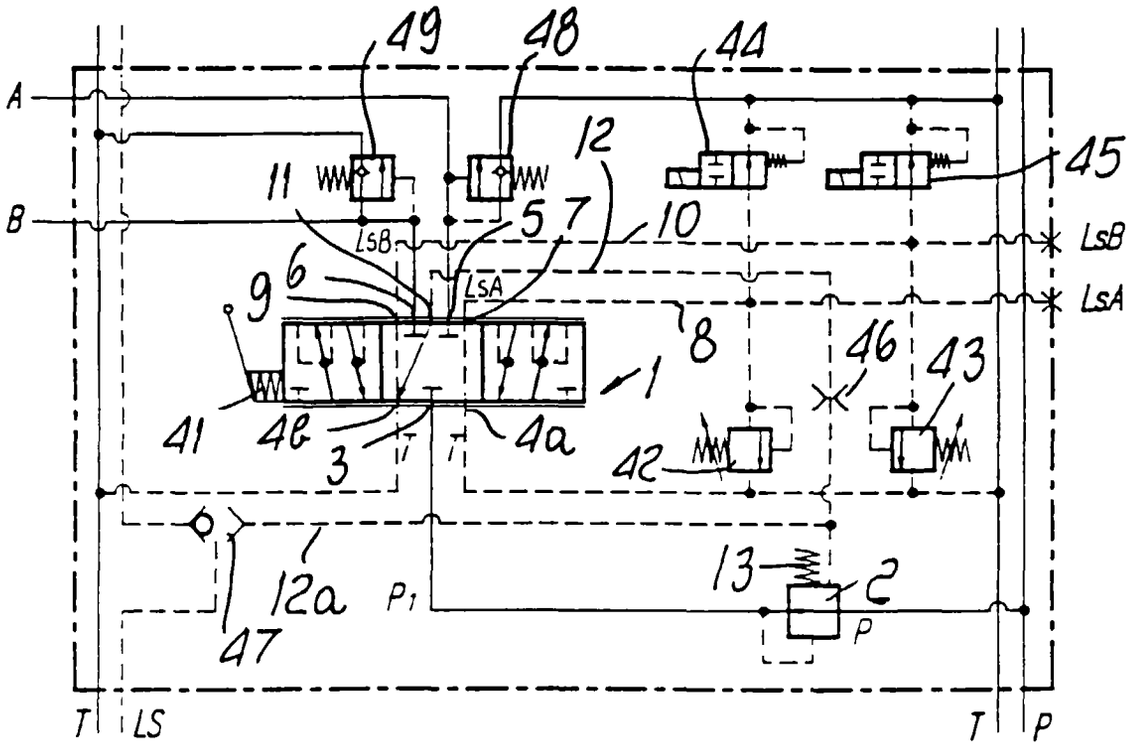
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Fig. 8

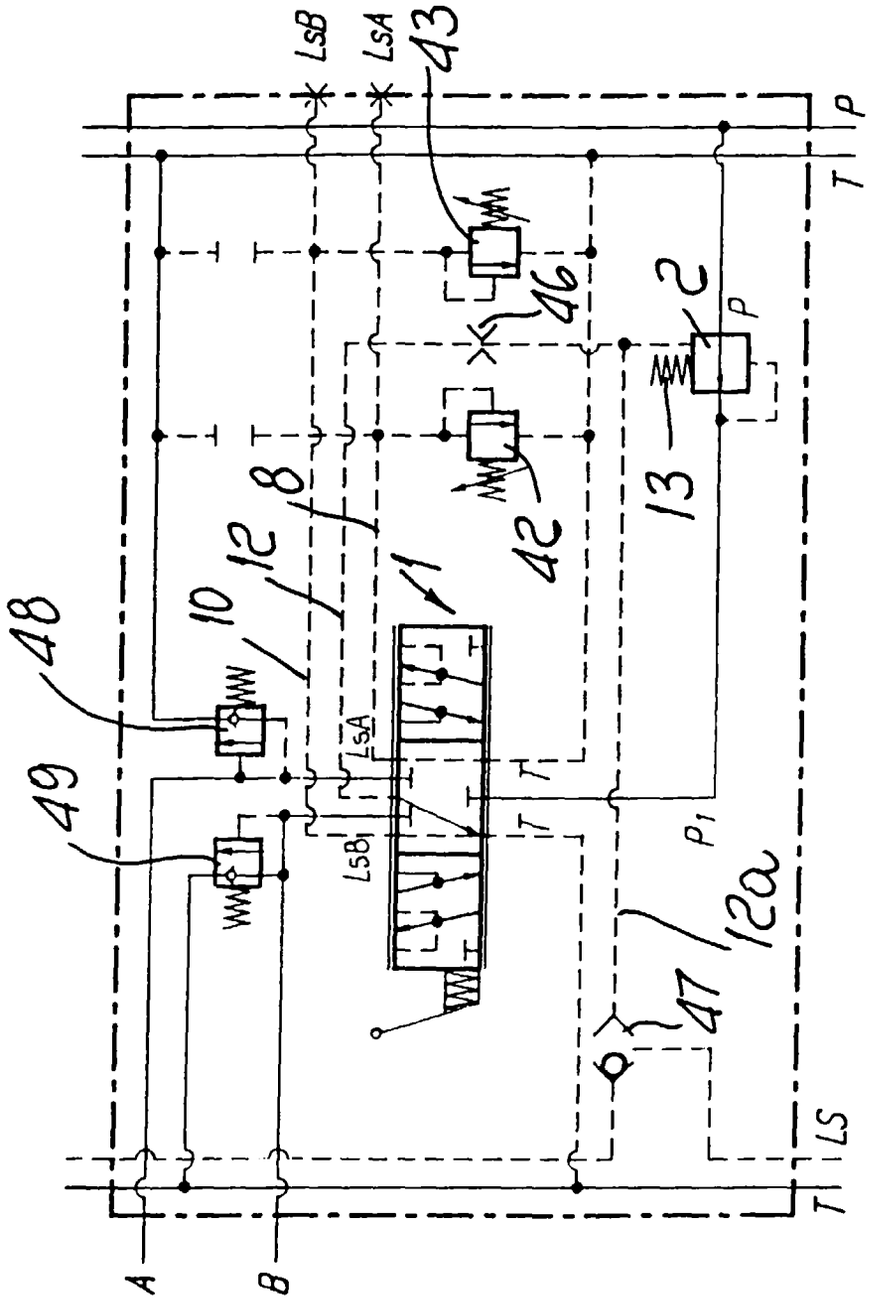

Fig. 9

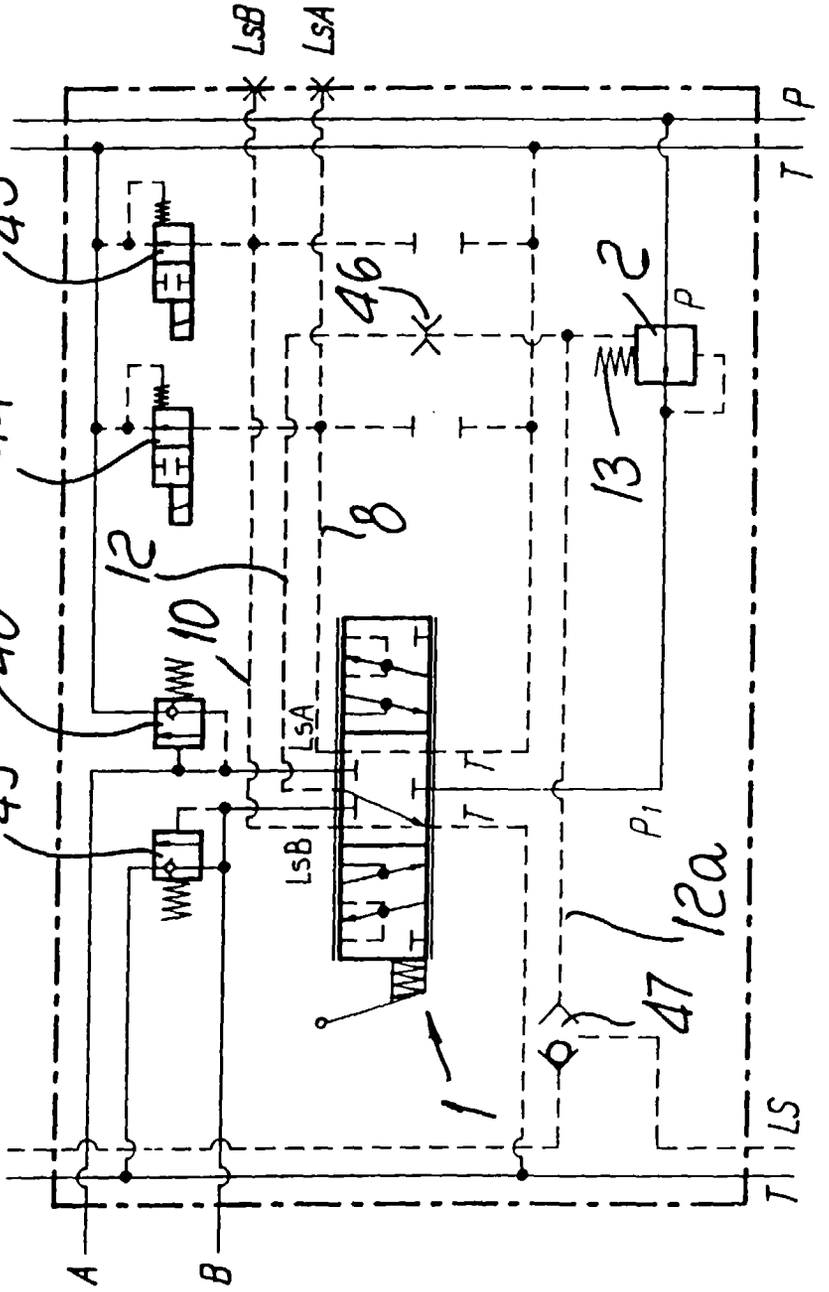

FIG.10

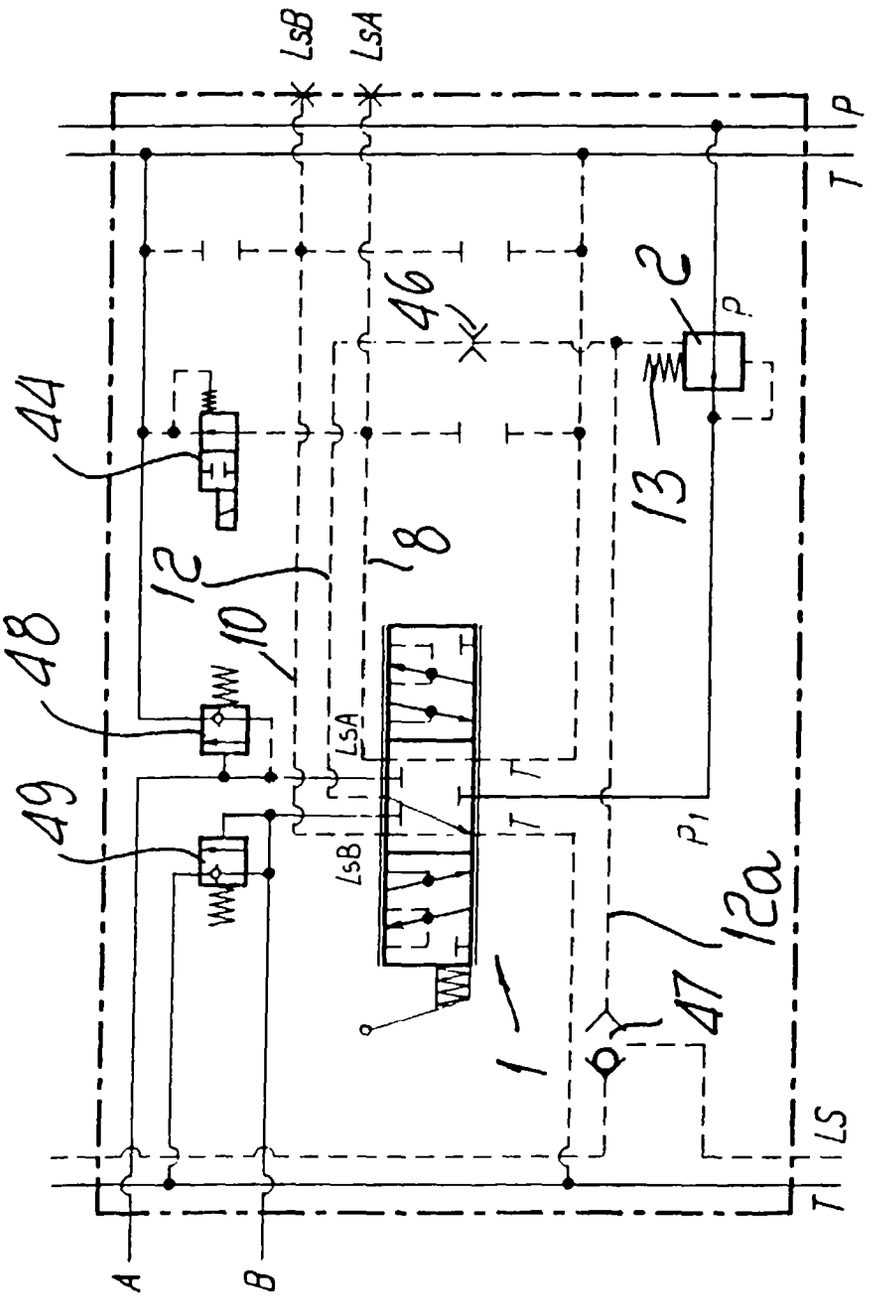

Fig. 11

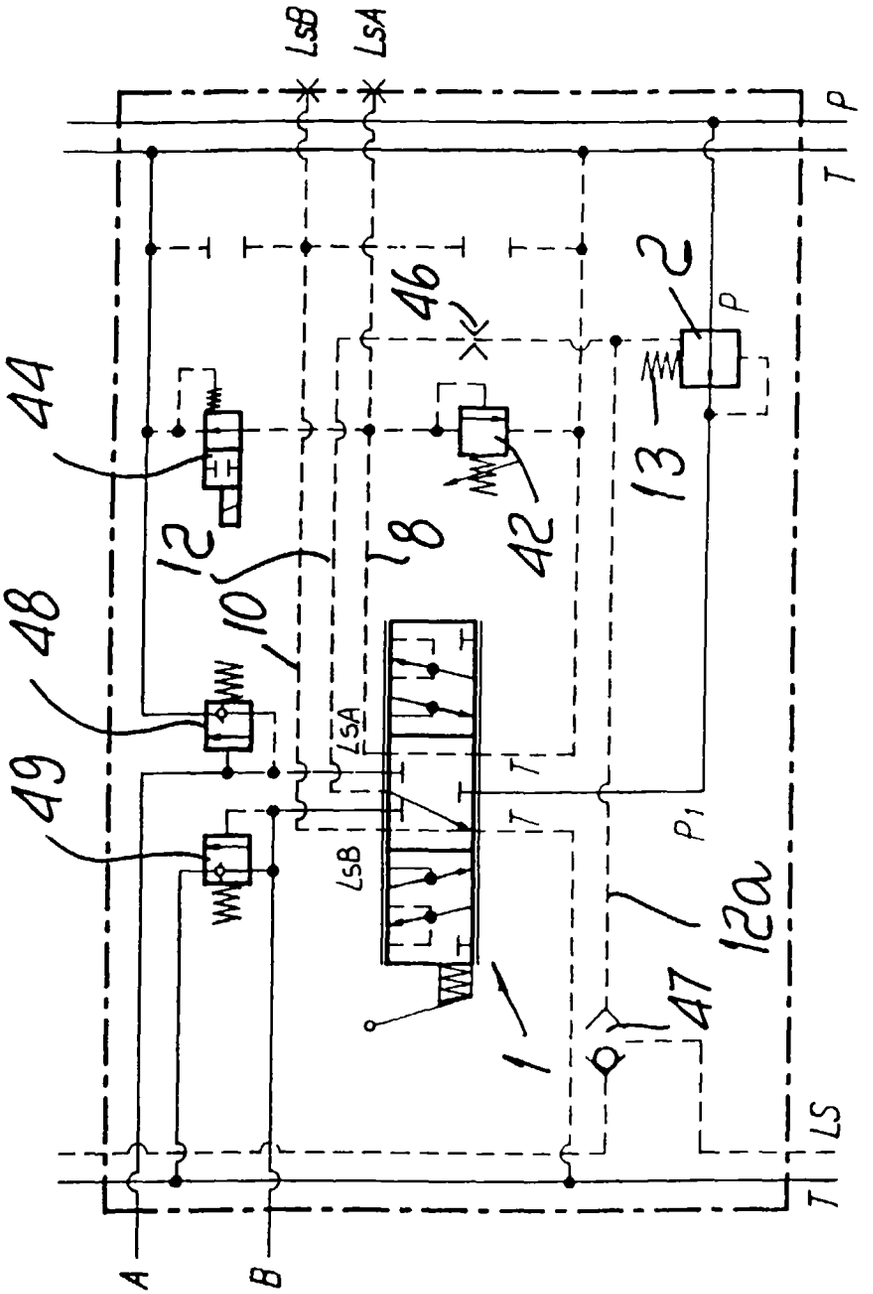

Fig. 12

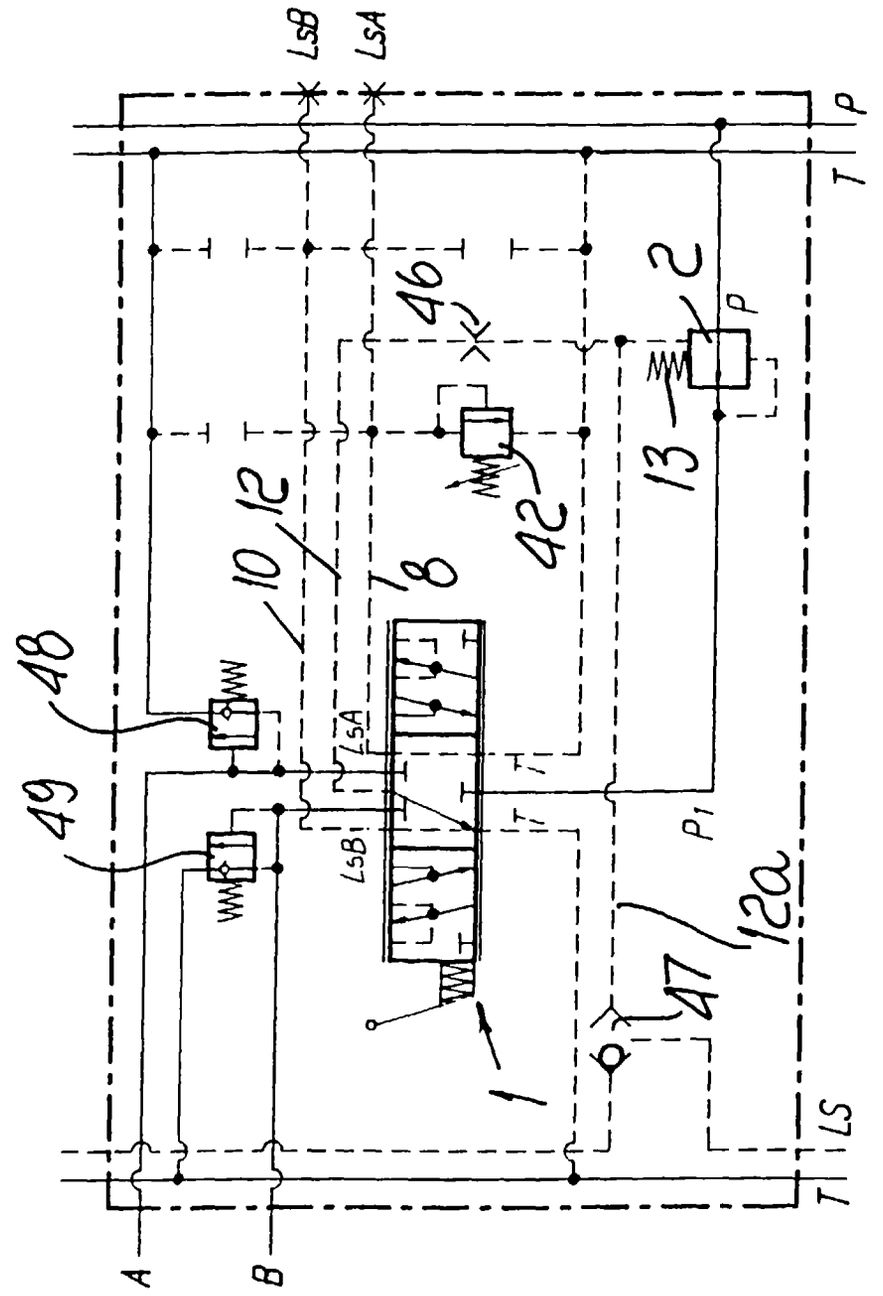

FIG. 13

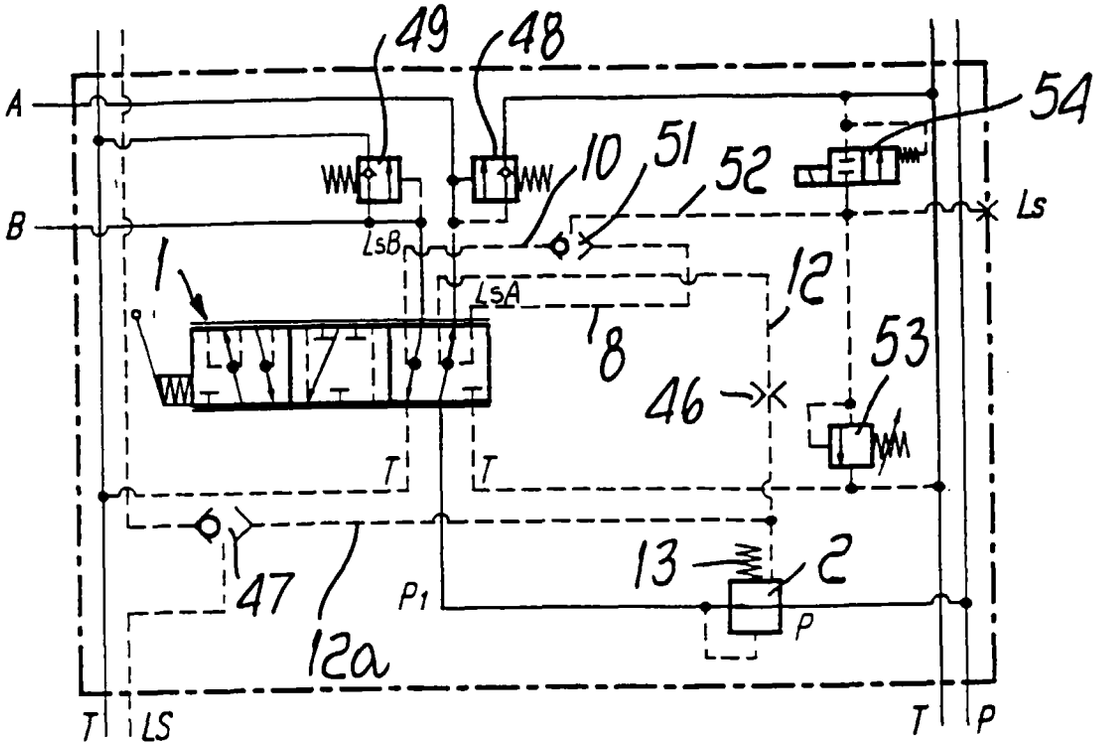
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Fig. 14

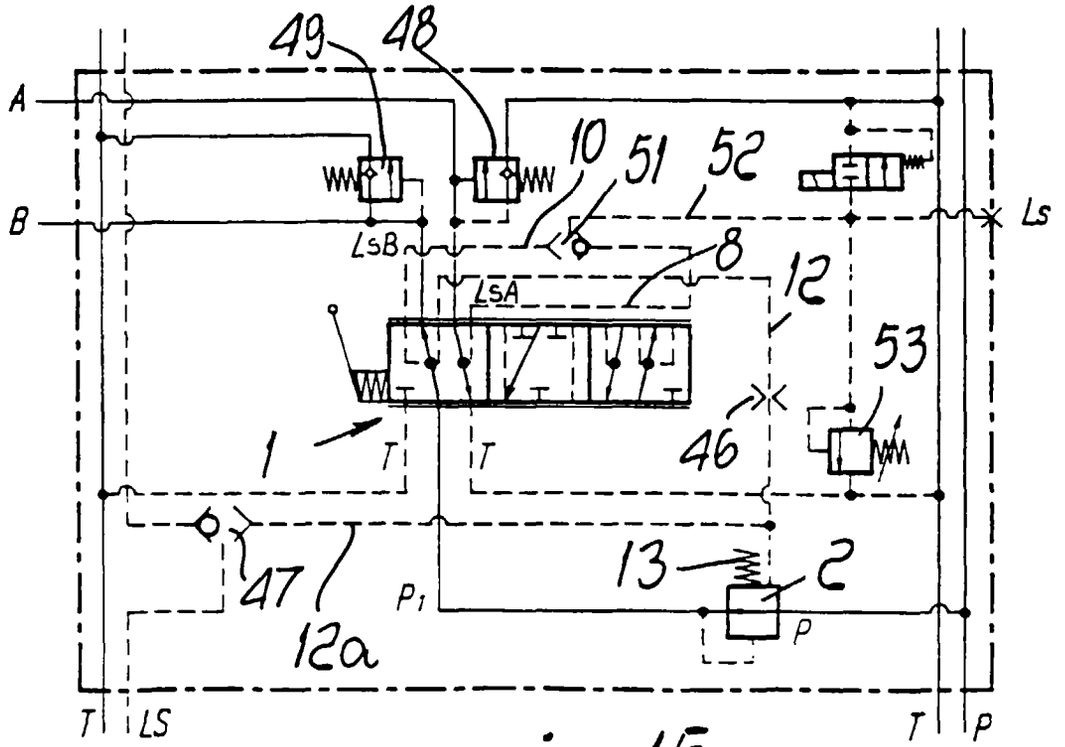
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Fig. 15

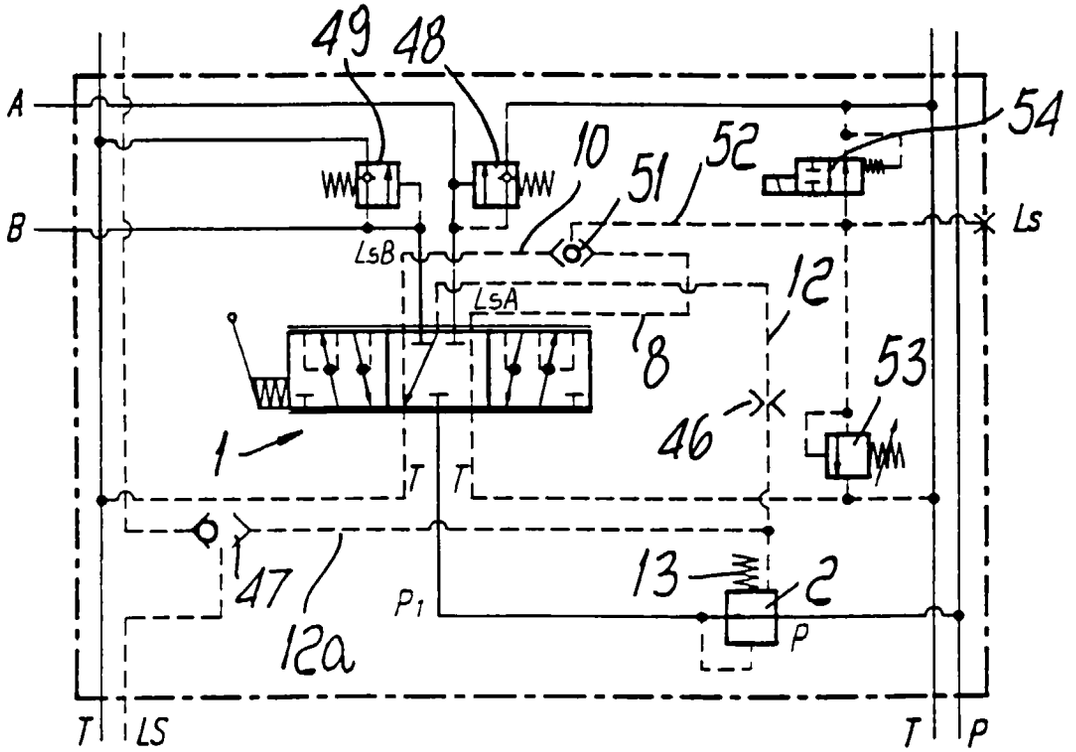

FIG. 16

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 10 0802

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,A	DE 38 41 507 C (DANFOSS A/S) 29 June 1989 * the whole document *	1	F15B11/05
A	DE 43 24 177 A (HEILMEIER & WEINLEIN) 17 February 1994 * the whole document *	1	
A	EP 0 224 936 A (SAUER GETRIEBE AG) 10 June 1987 * figure 6 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F15B
E02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	29 April 1997	Pöll, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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L : document cited for other reasons

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