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(54) **DISPLACEMENT ADJUSTMENT SYSTEM FOR A VARIABLE DISPLACEMENT PUMP**

VERDRÄNGUNGSEINSTELLUNGSSYSTEM FÜR EINE VARIABLE VERDRÄNGERPUMPE

SYSTÈME D'AJUSTEMENT DE DÉBIT POUR POMPE À DÉBIT VARIABLE

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Description

Field of the invention

[0001] The present invention relates to a displacement adjustment system for a variable displacement pump, in particular an adjustment system capable of adjusting the displacement by controlling a pressure prevailing inside a displacement adjustment chamber of the pump.

Prior art

[0002] Variable displacement rotary volumetric pumps having a rotor, with a plurality of seats configured to guide the translational movement of vanes that rotate between a stator and one or more centering rings, are known. The stator is configured to be moved in such a way as to vary the relative distance between its axis and the axis of rotation of the rotor, thereby varying the displacement of the pump and hence the pressure at which the liquid is sent out of the pump. The displacement is adjusted by varying the pressure prevailing inside a displacement adjustment chamber. An increase in pressure inside said chamber generates a thrust on the stator, which causes the latter to move from a configuration of maximum displacement to a configuration of minimum displacement. The movement, which is generally a pivoting movement, of the stator also causes the compression of a resilient return element necessary to bring the system back into the configuration of maximum displacement when the pressure inside the adjustment chamber falls. This type of displacement adjustment, in which a single adjustment chamber is configured to generate a thrust that acts against a resilient return element, is referred to as incremental adjustment.

[0003] Variable displacement pumps of the above type are used, for example, to circulate lubricating oil in an internal combustion engine. The variable displacement makes it possible to adjust the flow of lubricating oil, optimizing same according to the mode of operation of the engine, maximizing said flow at low engine speeds, so as to ensure sufficient lubrication, and reducing said flow at high engine speeds, so as to limit consumption by the engine (which drives the pump), limit the pressure and hence the stress on the lubrication circuit.

[0004] Also known are displacement adjustment systems for rotary volumetric pumps of the above type which act by controlling the pressure prevailing inside the displacement adjustment chamber. For example, WO2015160178A1 describes an adjustment system comprising a spool valve for pressure control, of incremental type (i.e. in which a thrust acting on the spool is counteracted by a resilient return element). The spool of the valve has a first piston and a second piston, having identical working sections, separated by a portion of smaller section. The first piston has a thrust area connected to a supply duct of the pump, while a return spring acts against the second piston, in opposition to the thrust area of the first piston. The control valve also has a first pipe and a second pipe connected selectively and alternatively, by means of the valve spool, to the displacement adjustment chamber of the pump, and a third pipe connected selectively and alternatively to the pump supply duct or to a tank containing the liquid to be pumped by means of a 3/2 valve.

[0005] Document DE 102 34 621 A1 discloses an adjustment system for a variable displacement pump. The system comprises a pressure control spool valve that includes a spool having a first piston and a second piston. The second piston has a thrust area hydraulically connected with a tank of liquid by means of a pressure relief valve. Said valve is configured to open when the pressure acting against the thrust area of the second piston exceeds a predetermined threshold pressure.

[0006] Document WO 2012/113437 A1 discloses an adjustment system for a variable displacement pump. The pump comprises a first adjustment chamber, acting against a spring and always connected to the outlet of the pump, and a second adjustment chamber, acting concordant with the spring. The system comprises a pressure control spool valve that includes a spool having a first piston and a second piston. In the body of the spool valve a first adjustment pipe and a second adjustment pipe are provided. The hydraulic connection between the first adjustment pipe and the second adjustment pipe is aimed to lower the pressure in the second adjustment chamber of the pump.

[0007] Document US 2013/209302 A1 discloses an adjustment system for a variable displacement pump. The system comprises a pressure control spool valve that includes a spool having a first piston and a second piston. The trust area of the second piston is hysraulically connected directly to the oil tank of the system.

[0008] The Applicant has observed that the known system for controlling the pressure prevailing inside the displacement adjustment chamber of a variable displacement pump by incremental adjustment of displacement poses the problem that it is too complex, and therefore expensive, owing to the high number of pipes present in the pressure control valve and owing to the use of a spool with two pistons of equal working section, which thus comprise two differences in section along the spool.

[0009] A further problem with the known system arises from the fact that the need to use a spool with two pistons of equal working section makes it difficult to reduce the size of the spool. This means that the spool takes up more space and results in longer response times during changes in displacement owing to the greater volumes of liquid that it is necessary to move in order to move the spool.

[0010] It is an aim of the present invention to overcome the problems and limitations of the prior art by providing a displacement adjustment system for a variable displacement pump which is less complex, and therefore more economical, and which affords quicker response times during changes in displacement.

[0011] This and other aims are achieved with the displacement adjustment system for a variable displacement pump as claimed in the attached claims.

Description of the invention

[0012] The displacement adjustment system for a variable displacement pump according to the present invention comprises a variable displacement pump and a pressure control spool valve.

[0013] The variable displacement pump is preferably a rotary volumetric pump with vanes, comprising a rotor, a stator configured to be moved in such a way as to vary the eccentricity between its axis and the axis of rotation of the rotor, thereby varying the displacement of the pump, an intake port hydraulically connected to a tank of liquid, an outlet port, a displacement adjustment chamber, preferably a single chamber, configured in such a way that a pressure prevailing inside same generates a hydraulic thrust on the stator capable of moving the stator, causing a change in said eccentricity, and a resilient element configured to counteract said hydraulic thrust acting on the stator.

[0014] The pressure control spool valve comprises an outer valve body, a spool capable of sliding in the valve body, having a first piston and a second piston, and a resilient return element. The first piston has a thrust area hydraulically connected, preferably in stable mode, to the outlet port by means of a first outlet duct, in such a way that a hydraulic thrust acts on said thrust area of the first piston. The resilient return element is configured to oppose the hydraulic thrust acting on the thrust area of the first piston. The second piston has a thrust area of opposite direction to the thrust area of the first piston and hydraulically connected, selectively, to the tank of liquid, in such a way that a hydraulic thrust acts on said thrust area of the second piston in opposition to the hydraulic thrust acting on the thrust area of the first piston.

[0015] Advantageously, the presence of thrust areas of opposite directions makes it possible to have a more compact spool of more simple geometry.

[0016] The control valve further comprises, provided in the outer valve body, a first adjustment pipe, hydraulically connected to the adjustment chamber of the pump, and a second adjustment pipe, hydraulically connected to the tank of liquid. The first and second pipes are hydraulically connected to one another selectively, by means of the spool.

[0017] The low number of pipes present in the outer valve body makes it possible to simplify the system, lowering production costs.

[0018] By means of the pressure control spool valve, the displacement adjustment chamber is hydraulically connected, selectively, to the outlet port of the pump. Preferably, the displacement adjustment chamber is hydraulically connected to the outlet port of the pump only by means of the pressure control spool valve. This advantageously reduces the number of ducts necessary for operation of the adjustment system.

[0019] According to the present invention, the thrust area of the second piston of the spool has a smaller surface area than the thrust area of the first piston of the spool, in such a way that, for equal pressure exerted on the two thrust areas, the hydraulic thrust acting on the thrust area of the first piston is greater than the hydraulic thrust acting on the thrust area of the second piston.

[0020] Advantageously, the spool of the pressure control valve comprises a single difference in section between the first piston and the second piston. This simplified geometry advantageously makes it possible to lower production costs and produce an axially more compact spool.

[0021] In accordance with a first embodiment of the invention, the spool of the pressure control valve comprises a pipe made integral with said spool, which hydraulically connects the thrust area of the first piston of the spool to the thrust area of the second piston of the spool.

[0022] In accordance with this first embodiment, the thrust area of the second piston is hydraulically connected, selectively, to the tank of liquid by means of a 2/2 valve. The possibility of using a simple 2/2 valve instead of more complex valves advantageously represents a further simplification of the adjustment system according to the invention.

[0023] In accordance with a second embodiment of the invention, the thrust area of the second piston of the spool of the pressure control valve is hydraulically connected, selectively, to the tank or to the outlet port of the pump, alternatively. This alternative selective connection is achieved preferably by means of a 3/2 valve.

[0024] The present invention also relates to a method for adjusting the displacement of a variable displacement pump by means of the adjustment system described above.

[0025] The adjustment method comprises the steps of:

- placing the adjustment chamber of the pump in hydraulic connection with the tank of liquid, selectively, by means of the pressure control valve, so as to cause the pump to operate in the configuration of maximum displacement;
- under the action of the hydraulic thrust that acts on the thrust area of the first piston of the spool, placing the adjustment chamber of the pump in hydraulic connection with the outlet port of the pump, by means of the pressure control valve, so as to cause the pump to operate in the configuration of minimum displacement in a first stable outlet pressure mode;
- placing the thrust area of the second piston of the spool in hydraulic connection with the tank of liquid, selectively, so as to cause the pump to operate in the configuration of minimum displacement in a second stable outlet pressure mode lower than the first stable outlet pressure mode.

[0026] The adjustment method in accordance with the first embodiment of the invention further comprises the step of:

- placing the thrust area of the first piston of the spool in hydraulic connection with the thrust area of the second piston of the spool through the pipe made integral with the spool.

[0027] The adjustment method in accordance with the second embodiment of the invention further comprises the step of:

- placing the thrust area of the second piston of the spool in hydraulic connection with the outlet port of the pump, selectively.

[0028] This latter step is preferably not implemented simultaneously with said step of placing the thrust area of the second piston of the spool in hydraulic connection with the outlet port of the pump.

[0029] Advantageously, the fact that the spool is more compact makes it possible to reduce the volumes of liquid that it is necessary to move in order to move the spool, thereby reducing the response times when changing between the abovementioned two stable outlet pressure modes.

Brief Description of the Figures

[0030] These and other features and advantages of the present invention will become clearer from the following description of preferred embodiments provided by way of nonlimiting example with the aid of the accompanying figures, in which elements indicated by the same or a similar reference numeral denote elements that have the same or a similar functionality and structure. In these figures:

- figure 1 is a schematic view showing a displacement adjustment system for a variable displacement pump according to a first embodiment of the present invention;
- figure 2 is a front view of a variable displacement pump, without a cover, included in the adjustment system of figure 1;
- figure 3 is a view in section of a pressure control valve included in the adjustment system of figure 1;
- figure 4a is a schematic view showing the first embodiment of the adjustment system, in a first working configuration, during a first operating step;
- figure 4b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 4a;
- figure 5a is a schematic view showing the first embodiment of the adjustment system, in the first working configuration, during a second operating step;
- figure 5b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 5a;
- figure 6a is a schematic view showing the first embodiment of the adjustment system, in a second working configuration, during a first operating step;
- figure 6b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 6a;
- figure 7a is a schematic view showing the first embodiment of the adjustment system, in a second working configuration, during a second operating step;
- figure 7b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 7a;
- figure 8 is a schematic view showing a displacement adjustment system for a variable displacement pump according to a second embodiment of the present invention;
- figure 9 is a view in section of a pressure control valve included in the adjustment system of figure 8;
- figure 10a is a schematic view showing the second embodiment of the adjustment system, in a first working configuration, during a first operating step;
- figure 10b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 10a;
- figure 11a is a schematic view showing the second embodiment of the adjustment system, in the first working configuration, during a second operating step;
- figure 11b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 11a;
- figure 12a is a schematic view showing the second embodiment of the adjustment system, in a second working configuration, during a first operating step;
- figure 12b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 12a;
- figure 13a is a schematic view showing the second embodiment of the adjustment system, in a second working configuration, during a second operating step;
- figure 13b is a graph showing the evolution of the pressure of the liquid pumped, as a function of the speed of rotation of the rotor of the pump in the adjustment system of figure 13a.

Description of some Preferred Embodiments of the Invention

[0031] With reference to figure 1, a first embodiment of a system 10 for adjusting the displacement of a variable displacement pump 11 according to the invention is described below.

[0032] The displacement adjustment system 10 comprises a variable displacement rotary volumetric pump 11, having a displacement adjustment chamber 13, and a pressure control valve 30 configured to control the pressure prevailing inside the displacement adjustment chamber 13 of the pump 11.

[0033] With reference to figure 2, the variable displacement pump 11 comprises, inside a body 12 of the pump, a hollow stator 14 and a rotor 15 mounted inside the stator 14. The rotor 15 has a fixed axis of rotation Y while the stator 14 is mounted movably, in such a way that it can vary the eccentricity between its axis X and the axis of rotation Y of the rotor 15, thus varying the displacement of the pump 11.

[0034] Preferably, the rotor 15 of the pump 11 comprises a plurality of seats 15a configured to guide the translational movement of vanes 16 that rotate between one or more centering rings 17 and the stator 14.

[0035] The pump 11 further comprises an intake port 18, hydraulically connected to a tank 60 of liquid to be pumped, and an outlet port 19.

[0036] The displacement adjustment chamber 13, preferably made in the body 12 of the pump 11 and partially defined by an outer surface 14a of the stator 14, is intended to fill with a liquid pumped by the pump 11 and is configured in such a way that a pressure prevailing inside the chamber generates a thrust on the stator 14 capable of moving said stator, thereby varying the eccentricity between its axis X and the axis of rotation Y of the rotor 15. In particular, the thrust generated in the displacement adjustment chamber 13, reducing the eccentricity, causes the stator 14 to move from a configuration of maximum displacement into a configuration of minimum displacement.

[0037] In accordance with the present embodiment, the movement of the stator 14 under the effect of the thrust generated in the adjustment chamber 13 takes the form of pivoting. In accordance with other embodiments, the movement may take another form, for example rotary or translational.

[0038] The pump 11 further comprises a resilient element 20, for example a spring, capable of counteracting the thrust acting on the stator 14 generated in the displacement adjustment chamber 13 and bringing the pump 11 back to maximum eccentricity and, hence, to maximum displacement.

[0039] Preferably, the pump 11 comprises a single displacement adjustment chamber 13 and the adjustment of the displacement is of incremental type, as there is a single thrust, generated in said single adjustment chamber 13, which acts against the resilient return element 20 and causes, once a given switching threshold has been exceeded, the variation of the displacement of the pump 11.

[0040] With particular reference to figure 3, the control valve 30 of the adjustment system 10 is a spool valve comprising an outer valve body 31, a spool 32 which has a first piston 33 and a second piston 34 and is capable of sliding inside the valve body 31, and a resilient return element 38.

[0041] The first piston 33 of the spool 32 has a thrust area 33a that defines, together with the outer valve body 31, a first chamber 35 of the control valve 30 (namely the control valve supply chamber).

[0042] The resilient return element 38 of the control valve 30 is housed inside the second piston 34 of the spool 32 has a thrust area 34a, of opposite direction and, preferably, with a smaller surface area than the thrust area 33a of the first piston 33, which defines, together with the outer valve body 31, a second chamber 36 of the control valve 30 (namely the control valve counter-thrust chamber).

[0043] The first chamber 35 and the second chamber 36 of the control valve 30 are hydraulically connected by means of a pipe 37 made integral with the spool 32, in a longitudinal direction. This pipe 37 has appropriate dimensions so as to limit the flow rate of liquid passing through between the first and the second chambers 35, 36, limiting flow rate losses owing to leakage to the tank 60.

[0044] the second chamber 36 of the control valve 30. In particular, the resilient element 38 is, for example, a spring having a first end 38a in abutment against the thrust area 34a of the second piston 34 of the spool 32 and a second end 38b in abutment against an end wall 31a of the outer valve body 31 so as to act in opposition to a hydraulic thrust exerted on the thrust area 33a of the first piston 33.

[0045] The spool 32 of the control valve 30 comprises, preferably, a single difference in section between the first piston 33 and the second piston 34. This simplified geometry advantageously makes it possible to reduce production costs and produce a more axially compact spool.

[0046] A first pipe 39, which may be partially obstructed by the first piston 33 of the spool 32, and a second pipe 40, both arranged radially with respect to the direction of sliding of the spool 32, are provided in the valve body 31 of the control valve 30. The first pipe 39 is hydraulically connected to the displacement adjustment chamber 13 while the second pipe 40 is hydraulically connected to the tank of liquid 60.

[0047] By means of the spool 32, the first pipe 39, and hence the displacement adjustment chamber 13, is hydraulically connected alternatively to the first chamber 35 of the control valve 30, and hence to the outlet port 19 of the pump 11, or to the second pipe 40 of the control valve 30, and hence to the tank of liquid 60, or is hydraulically connected simultaneously to the first chamber 35 and to the second pipe 40. In particular, the sliding of the spool 32 causes the control valve 30 to switch from a first state, in which the first piston 33 closes off the hydraulic connection between the first pipe 39 and the first chamber 35 of the control valve 30, leaving open the hydraulic connection between the first pipe 39 and the second pipe 40, to a second state, in which the first piston 33 closes off the hydraulic connection between the first pipe 39 and the second pipe 40, leaving open the hydraulic connection between the first pipe 39 and the first chamber 35 of the control valve 30. In addition to the above two states, there is also an intermediate state in which the first piston 33 only partially obstructs the hydraulic connection between the first pipe 39 and the second pipe 40 and between the first pipe 39 and the first chamber 35 of the control valve 30.

[0048] The adjustment system 10 further comprises a supply duct 50 for supplying a user member 51 that uses the liquid pumped, for example an internal combustion engine, which supply duct runs between the outlet port 19 and said user member 51 and along which is arranged, preferably, a filter 52.

[0049] A first outlet duct 53 of the adjustment system 10, branching off from the supply duct 50, preferably downstream of the filter 52 (with reference to the direction of flow of the liquid in the supply duct 50), hydraulically connects the first chamber 35 of the control valve 30 to the outlet port 19 of the pump 11. Thus, when the pump 11 is in use, a hydraulic thrust acts on the thrust area 33a of the first piston 33 of the spool 32. In particular, the first chamber 35 of the control valve 30 is hydraulically connected to the outlet port 19 of the pump 11 in stable mode and therefore the thrust area 33a of the first piston 33 is referred to as a passive thrust area.

[0050] The adjustment system 10 further comprises a discharge valve 55, for example a 2/2 (i.e. two-way, two-position) solenoid valve, for hydraulically connecting, selectively, the second chamber 36 of the control valve 30 to the tank of liquid 60. Thus, a variable hydraulic thrust may act on the thrust area 34a of the second piston 34, referred to as an active counterthrust area, in opposition to the hydraulic thrust that acts on the thrust area 33a of the first piston 33. This hydraulic thrust acting on the thrust area 34a of the second piston 34 is greater in the case in which the discharge valve 55 is closed (first configuration of the adjustment system) and smaller in the case in which the discharge valve 55 is open (second configuration of the adjustment system). As will be seen below in the description of the steps of the displacement adjustment method, this makes it possible to select, according to the requirements of the system, the pressure threshold for the pumped liquid that causes the control valve 30 to switch from the first to the second state and hence the pressure threshold beyond which the pump 11, reducing its displacement, operates in stable outlet pressure mode.

[0051] Since the control valve 30 has two thrust areas 33a, 34a against which the pumped liquid within the system exerts a pressure, the control valve 30 is a differential valve.

[0052] The displacement adjustment method in accordance with the first embodiment of the adjustment system 10 described above, will now be described below.

[0053] With reference to figures 4a and 5a, in the adjustment system 10 in the first configuration, i.e. with the discharge valve 55 kept closed, the pressure of the pumped liquid, which has flowed into the first chamber 35 of the control valve 30 and, through the pipe 37 integral with the spool 32, into the second chamber 36 of the control valve 30, generates a net hydraulic thrust on the spool 32 proportional to the difference between the thrust areas 33a, 34a of the first and second pistons 33, 34 of the spool 32.

[0054] In a first operating step, shown in figure 4a, the balance of forces acting on the spool 32, resulting from said net hydraulic thrust and from the force exerted by the resilient element 38 of the control valve 30, keeps the control valve 30 in its first state, in which the first pipe 39 is in hydraulic connection with the second pipe 40 and not with the first chamber 35 of the control valve 30. In this step, therefore, the displacement adjustment chamber 13 is in hydraulic connection with the tank 60 and hence the pressure inside the chamber is low (in particular, below the threshold for switching the displacement of the pump), such that the stator 14 of the pump 11 remains in the configuration of maximum displacement.

[0055] In this first step, which begins with the start-up of the pump 11, the pressure of the liquid pumped increases in proportion to the speed of rotation of the rotor 15 of the pump 11, as shown in the portion A_{HP} of the graph of figure 4b.

[0056] In a second operating step of the adjustment system 10 in the first configuration, shown in figure 5a, the speed of rotation of the rotor 15 of the pump 11 is increased until the liquid pumped reaches a pressure value HP (above the threshold for switching the displacement of the pump). The pressure HP of the liquid pumped is such that the net hydraulic thrust acting on the spool 32, overcoming the force exerted by the resilient element 38 of the control valve 30, brings the control valve 30 into its intermediate state and hence into its second state, in which the first pipe 39 is in hydraulic connection with the first chamber 35 of the control valve 30. In this step, therefore, the displacement adjustment chamber 13 is in hydraulic connection with the outlet port 19 of the pump 11 and hence the pressure inside the chamber rises above the threshold for switching the displacement of the pump, such that the stator 14 of the pump 11 moves into the configuration of minimum displacement. Advantageously, the passage of the displacement adjustment valve 13 through the intermediate state, in which the pressure in the displacement adjustment chamber 13 assumes values between the pressure of the liquid in the outlet duct 53 and the pressure of the liquid in the tank 60, as a function of local leakage from the first piston 33 of the spool 32, allows gradual switching of the displacement of the pump.

[0057] In said second operating step, the pressure of the liquid pumped remains stable, equal to HP, when the speed of rotation of the rotor 15 of the pump 11 increases, as shown in the portion C of the graph of figure 5b.

[0058] With reference to figures 6a and 7a, in the case in which the adjustment system 10 is operating in its second configuration, i.e. with the discharge valve 55 kept open, the spool 32 is subjected to a hydraulic thrust exerted on the thrust area 33a of the first piston 33 by the liquid pumped and a hydraulic thrust exerted on the thrust area 34a of the second piston 34 by the liquid contained in the second chamber 36 of the control valve 30, at a pressure lower than the liquid acting on the thrust area 33a of the first piston 33 since the second chamber 36 of the control valve 30 is in hydraulic connection with the tank 60.

[0059] In a first operating step, shown in figure 6a, the balance of forces acting on the spool 32, resulting from said hydraulic thrusts and from the force exerted by the resilient element 38 of the control valve 30, keeps the control valve 30 in its first state, in which the first pipe 39 is in hydraulic connection with the second pipe 40 and not with the first chamber 35 of the control valve 30. In this step, therefore, the displacement adjustment chamber 13 is in hydraulic connection with the tank 60 and hence the pressure inside the chamber is low (in particular, below the threshold for switching the displacement of the pump), such that the stator 14 of the pump 11 remains in the configuration of maximum displacement.

[0060] In this first step, which begins with the start-up of the pump 11, the pressure of the liquid pumped increases in proportion to the speed of rotation of the rotor 15 of the pump 11, as shown in the portion A_{LP} of the graph of figure 6b.

[0061] In a second operating step of the adjustment system 10 in the second configuration, shown in figure 7a, the speed of rotation of the rotor 15 of the pump 10 is increased until the liquid pumped reaches a pressure value LP (above the threshold for switching the displacement of the pump). The pressure LP of the liquid pumped is such that the hydraulic thrust exerted on the thrust area 33a of the first piston 33, overcoming the hydraulic thrust exerted on the thrust area 34a of the second piston 34 and the force exerted by the resilient element 38 of the control valve 40, brings the control valve 30 into its intermediate state and hence into its second state, in which the first pipe 39 is in hydraulic connection with the first chamber 35 of the control valve 30. In this step, therefore, the displacement adjustment chamber 13 is in hydraulic connection with the outlet port 19 of the pump 11 and hence the pressure inside the chamber rises above the threshold for switching the displacement of the pump, such that the stator 14 of the pump 11 moves into the configuration of minimum displacement. Advantageously, the passage of the displacement adjustment valve 13 through the intermediate state, in which the pressure in the displacement adjustment chamber 13 assumes values between the pressure of the liquid in the outlet duct 53 and the pressure of the liquid in the tank 60, as a function of local leakage from the first piston 33 of the spool 32, allows gradual switching of the displacement of the pump.

[0062] In said second operating step, the pressure of the liquid pumped remains stable when the speed of rotation of the rotor 15 of the pump 11 increases, as shown in the portion B of the graph of figure 7b.

[0063] Because it is possible, by opening the discharge valve 55, to reduce the pressure in the second chamber 36 of the control valve 30, the pressure value LP reached during the stable outlet pressure mode of the pump 11 when the adjustment system 10 is operating in its second configuration is lower than the corresponding stable pressure value HP reached by the pump 11 when the adjustment system 10 is operating in its first configuration.

[0064] With reference to figure 8, a second embodiment of a displacement adjustment system 110 of a variable displacement pump 111 according to the invention will now be described below.

[0065] The displacement adjustment system 110 comprises a variable displacement rotary volumetric pump 111, having a displacement adjustment chamber 113, and a control valve 130 configured to control the pressure prevailing inside the displacement adjustment chamber 113 of the pump 111.

[0066] The variable displacement rotary volumetric pump 111 of the second embodiment is the same as that of the first embodiment, shown in figure 2, reference being made to the description thereof.

[0067] The control valve 130 of the second embodiment, shown in figure 9, is the same as that of the first embodiment, reference being made to the description thereof, with the exception of the fact that the spool 132 does not have the pipe integral between the first chamber 135 and the second chamber 136 of the control valve 130.

[0068] As in the first embodiment, the first pipe 139 of the valve body 131 of the control valve 130 is hydraulically connected to the displacement adjustment chamber 113 of the pump 111 while the second pipe 140 is hydraulically connected to the tank of liquid 160.

[0069] As in the case of the first embodiment, owing to the sliding of the spool 132 in the valve body 131, the first pipe 139, and hence the displacement adjustment chamber 113, is alternatively connected, in a first state of the control valve 130, to the first chamber 135 of the control valve 130, and hence to the outlet port 119 of the pump 111, or, in a second state of the control valve 130, to the second pipe 140 of the control valve 30, and hence to the tank of liquid 160, or, in an intermediate state, is hydraulically connected simultaneously to the first chamber 135 and to the second pipe 140.

[0070] The adjustment system 110 comprises a supply duct 150 for supplying a user member 151 that uses the liquid pumped, for example an internal combustion engine, which supply duct runs between the outlet port 119 and said user member 151 and along which is arranged, preferably, a filter 152.

[0071] A first outlet duct 153 of the system, branching off from the supply duct 150, preferably downstream of the filter 152 (with reference to the direction of flow of the liquid in the supply duct 150), hydraulically connects the first chamber 135 of the control valve 130 to the outlet port 119 of the pump 111. Thus, when the pump 111 is in use, a hydraulic thrust acts on the thrust area 133a of the first piston 133 of the spool 132. In particular, the first chamber 135 of the control valve 130 is hydraulically connected to the outlet port 119 of the pump 111 in stable mode and therefore the thrust area 133a of the first piston 133 is referred to as a passive thrust area.

[0072] In accordance with the second embodiment, the adjustment system 110 comprises a discharge valve 155, for example a 3/2 (i.e. three-way, two-position) solenoid valve for alternatively connecting, selectively, the second chamber 136 of the control valve 130 respectively to the tank of liquid 160 or to a second outlet duct 154, branching off from the supply duct 150, preferably downstream of the filter 152. Thus, a variable hydraulic thrust may act on the thrust area 134a of the second piston 134, referred to as an active counterthrust area, in opposition to the hydraulic thrust that acts on the thrust area 133a of the first piston 133. This hydraulic thrust acting on the thrust area 134a of the second piston 134 is greater in the case in which the discharge valve 155 connects the second chamber 136 of the control valve 130 to the second outlet duct 154, and hence to the outlet port 119 of the pump 111 (first configuration of the adjustment system), and smaller in the case in which the discharge valve 155 connects said second chamber 136 to the tank 160 (second configuration of the adjustment system). As will be seen below in the description of the steps of the displacement adjustment method, this makes it possible to select, according to the requirements of the system, the pressure threshold for the pumped liquid that causes the control valve 130 to switch from the first to the second state and hence the pressure threshold beyond which the pump 111, reducing its displacement, operates in stable outlet pressure mode.

[0073] Since the control valve 130 has two thrust areas 133a, 134a against which the pumped liquid within the system exerts a pressure, the control valve 130 is a differential valve also in the case of the second embodiment.

[0074] The operation of the second embodiment of the adjustment system 110 described above, will now be described below.

[0075] With reference to figures 10a and 11a, in the adjustment system 110 in the first configuration, i.e. with the discharge valve 155 hydraulically connecting the second chamber 136 of the control valve 130 to the second outlet duct 154, the pressure of the pumped liquid, which has flowed into the first chamber 135 of the control valve 130 and, through the second outlet duct 154 and the discharge valve 155, into the second chamber 136 of the control valve 130, generates a net hydraulic thrust on the spool 132 proportional to the difference between the thrust areas 133a, 134a of the first and second pistons 133, 134 of the spool 132.

[0076] In a first operating step, shown in figure 10a, the balance of forces acting on the spool 132, resulting from said net hydraulic thrust and from the force exerted by the resilient element 138 of the control valve 130, keeps the control valve 130 in its first state, in which the first pipe 139 is in hydraulic connection with the second pipe 140 and not with the first chamber 135 of the control valve 130. In this step, therefore, the displacement adjustment chamber 113 is in hydraulic connection with the tank 160 and hence the pressure inside the chamber is low (in particular, below the threshold for switching the displacement of the pump), such that the stator 114 of the pump 111 remains in the configuration of maximum displacement.

[0077] In this first step, which begins with the start-up of the pump 111, the pressure of the liquid pumped increases in proportion to the speed of rotation of the rotor 115 of the pump 111, as shown in the portion A_{HP} of the graph of figure 10b.

[0078] In a second operating step of the adjustment system 110 in the first configuration, shown in figure 11a, the speed of rotation of the rotor 115 of the pump 111 is increased until the liquid pumped reaches a pressure value HP' (above the threshold for switching the displacement of the pump). The pressure HP' of the liquid pumped is such that the net hydraulic thrust acting on the spool 132, overcoming the force exerted by the resilient element 138 of the control valve 130, brings the control valve 130 into its intermediate state and hence into its second state, in which the first pipe 139 is in hydraulic connection with the first chamber 135 of the control valve 130. In this step, therefore, the displacement adjustment chamber 113 is in hydraulic connection with the outlet port 119 of the pump 111 and hence the pressure inside the chamber rises above the threshold for switching the displacement of the pump, such that the stator 114 of the pump 111 moves into the configuration of minimum displacement. Advantageously, the passage of the displacement adjustment valve 130 through the intermediate state, in which the pressure in the displacement adjustment chamber 130 assumes values between the pressure of the liquid in the outlet duct 153 and the pressure of the liquid in the tank 160, as a function of local leakage from the first piston 133 of the spool 132, allows gradual switching of the displacement of the pump.

[0079] In said second step, the pressure of the liquid pumped remains stable, equal to HP', when the speed of rotation of the rotor 115 of the pump 111 increases, as shown in the portion C of the graph of figure 11b.

[0080] With reference to figures 12a and 13a, in the case in which the adjustment system 110 in accordance with the second embodiment is operating in its second configuration, i.e. with the discharge valve 155 hydraulically connecting the second chamber 136 of the control valve 130 to the tank of liquid 160, the spool 132 is subjected to a hydraulic thrust exerted on the thrust area

133a of the first piston 133 by the liquid pumped and a hydraulic thrust exerted on the thrust area 134a of the second piston 134 by the liquid contained in the second chamber 136 of the control valve 130, at a pressure lower than the liquid acting on the thrust area 133a of the first piston 133 since the second chamber 136 of the control valve 130 is in hydraulic connection with the tank 160.

[0081] In a first operating step, shown in figure 12a, the balance of forces acting on the spool 132, resulting from said hydraulic thrusts and from the force exerted by the resilient element 138 of the control valve 130, keeps the control valve 130 in its first state, in which the first pipe 139 is in hydraulic connection with the second pipe 140 and not with the first chamber 135 of the control valve 130. In this step, therefore, the displacement adjustment chamber 113 is in hydraulic connection with the tank 160 and hence the pressure inside the chamber is low, in particular below the threshold for switching the displacement of the pump, such that the stator 114 of the pump 111 remains in the configuration of maximum displacement.

[0082] In this first step, which begins with the start-up of the pump 111, the pressure of the liquid pumped increases in proportion to the speed of rotation of the rotor 115 of the pump 111, as shown in the portion A_{LP} of the graph of figure 12b .

[0083] In a second operating step of the adjustment system 110 in the second configuration, shown in figure 13a, the speed of rotation of the rotor 115 of the pump 111 is increased until the liquid pumped reaches a pressure value LP' (above the threshold for switching the displacement of the pump). The pressure LP' of the liquid pumped is such that the hydraulic thrust exerted on the thrust area 133a of the first piston 133, overcoming the hydraulic thrust exerted on the thrust area 134a of the second piston 134 and the force exerted by the resilient element 138 of the control valve 130, brings the control valve 130 into its intermediate state and hence into its second state, in which the first pipe 139 is in hydraulic connection with the first chamber 135 of the control valve 130. In this step, therefore, the displacement adjustment chamber 113 is in hydraulic connection with the outlet port 119 of the pump 111 and hence the pressure inside the chamber rises above the threshold for switching the displacement of the pump, such that the stator 114 of the pump 111 moves into the configuration of minimum displacement. Advantageously, the passage of the displacement adjustment valve 130 through the intermediate state, in which the pressure in the displacement adjustment chamber 130 assumes values between the pressure of the liquid in the outlet duct 153 and the pressure of the liquid in the tank 160, as a function of local leakage from the first piston 133 of the spool 132, allows gradual switching of the displacement of the pump.

[0084] In said second operating step, the pressure of the liquid pumped remains stable when the speed of rotation of the rotor 115 of the pump 111 increases, as shown in the portion B of the graph of figure 13b.

[0085] Because it is possible, by opening the discharge valve 155, to reduce the pressure in the second chamber 136 of the control valve 130, the pressure value LP' reached during the stable outlet pressure mode of the pump 111 when the adjustment system 110 is operating in its second configuration is lower than the corresponding stable pressure value HP' reached by the pump 111 when the adjustment system 110 is operating in its first configuration.

[0086] The displacement adjustment system for a variable displacement pump as described and illustrated may be subject to further alternatives and modifications, all falling under the scope of the appended claims.

Claims

1. A displacement adjustment system (10; 110) for a variable displacement pump (11; 111), said system comprising

   - a variable displacement pump (11; 111) comprising a rotor (15; 115), a stator (14; 114) configured to be moved in such a way as to vary the eccentricity between its axis (X) and the axis of rotation (Y) of the rotor (15; 115), thereby varying the displacement of the pump (11; 111), an outlet port (19; 119), a displacement adjustment chamber (13; 113), configured in such a way that a pressure prevailing inside same generates a thrust on the stator (14; 114) capable of moving the stator (14; 114), causing a change in said eccentricity, and a resilient element (20; 120) capable of counteracting said thrust acting on the stator (14; 114),
   - a pressure control spool valve (30; 130) comprising an outer valve body (31; 131), a spool (32; 132) capable of sliding in said valve body (31; 131) and having a first piston (33; 133) and a second piston (34; 134), and a resilient return element (38; 138), said first piston (33; 133) having a thrust area (33a; 133a), which defines, together with the valve body (31; 131), a first chamber (35; 135) of the pressure control spool valve (30; 130) and which is hydraulically connected to the outlet port (19; 119) of the pump (11; 111) by means of a first outlet duct (53; 153), in such a way that a hydraulic thrust acts on said thrust area (33a; 133a) of the first piston (33; 133), said resilient return element (38; 138) being configured to oppose said hydraulic thrust acting on the thrust area (33a; 133a) of the first piston (33; 133), said pressure control spool valve (30; 130) further comprising, provided in the outer valve body (31; 131), a first adjustment pipe (39; 139), hydraulically connected to the displacement adjustment chamber (13; 113), and a second adjustment pipe (40; 140), hydrau-

lically connected to a tank of liquid (60; 160) and selectively, by means of said spool (32; 132), to the first adjustment pipe (39; 139),

in which said displacement adjustment chamber (13; 113) is hydraulically connected to the outlet port (19; 119) of the pump (11; 111) through said pressure control spool valve (30; 130), selectively,
whereby, in a first state of the pressure control spool valve (30; 130), the first piston (33; 133) is configured to close off the hydraulic connection between the first adjustment pipe (39; 139) and the first chamber (35; 135) of the pressure control spool valve (30; 130), and to leave open the hydraulic connection between the first adjustment pipe (39; 139) and the second adjustment pipe (40; 140), and, in a second state of the pressure control spool valve (30; 130), the first piston (33; 133) is configured to close off the hydraulic connection between the first adjustment pipe (39; 139) and the second adjustment pipe (40; 140), and to leave open the hydraulic connection between the first adjustment pipe (39; 139) and the first chamber (35; 135) of the pressure control spool valve (30; 130),
in which said second piston (34; 134) of the pressure control spool valve (30; 130) has a thrust area (34a; 134a) of opposite direction to the thrust area (33a; 133a) of the first piston (33; 133),
characterized in that said thrust area (34a; 134a) of said second piston (34; 134) is hydraulically connected, selectively, with the tank of liquid (60; 160), by means of a solenoid valve (55; 155), in such a way that a hydraulic thrust acts on said thrust area (34a; 134a) of the second piston (34; 134) in opposition to said hydraulic thrust acting on the thrust area (33a; 133a) of the first piston (33; 133).

2. The adjustment system (10; 110) as claimed in claim 1, in which, in an intermediate state of the pressure control spool valve (30; 130), the first piston (33; 133) is configured to only partially obstruct the hydraulic connection between the first adjustment pipe (39; 139) and the second adjustment pipe (40; 140) and between the first adjustment pipe (39; 139) and the first chamber (35; 135) of the pressure control spool valve (30; 130).

3. The adjustment system (10; 110) as claimed in claim 1 or 2, in which the thrust area (34a; 134a) of the second piston (34; 134) of the spool (32; 132) has a smaller surface area than the thrust area (33a; 133a) of the first piston (33; 133) of the spool (32; 132).

4. The adjustment system (10; 110) as claimed in any of the preceding claims, in which said spool (32; 132) comprises a single difference in section between the first piston (33; 133) and the second piston (34; 134).

5. The adjustment system (10) as claimed in any of the preceding claims, in which the spool (32) comprises a pipe (37) made integral therewith and hydraulically connecting the thrust area (33a) of the first piston (33) of the spool (32) to the thrust area (34a) of the second piston (34) of the spool (32).

6. The adjustment system (10) as claimed in claim 1, in which the solenoid valve (55) that hydraulically connects, selectively, the thrust area (34a) of the second piston (34) to the tank of liquid (60) is a 2/2 valve (55).

7. The adjustment system (110) as claimed in any of claims 1 to 4, in which the thrust area (134a) of the second piston (134) is hydraulically connected, selectively, by means of said solenoid valve (155), to the tank of liquid (160) or to the outlet port (119) of the pump (111), alternatively.

8. The adjustment system (110) as claimed in claim 7, in which the solenoid valve (155) is a 3/2 valve.

9. A method for adjusting the displacement of a variable displacement pump (11; 111) comprising a displacement adjustment chamber (13; 113), by means of an adjustment system (10; 110) comprising a pressure control spool valve (30; 130), said method comprising the steps of:

- placing the displacement adjustment chamber (13; 113) of the pump (11; 111) is in hydraulic connection with a tank of liquid (60; 160), by means of the pressure control spool valve (30; 130), and not with an outlet port (19; 119) of the pump (11; 111), so as to cause the pump (11; 111) to operate in the configuration of maximum displacement;
- under the action of a hydraulic thrust that acts on a thrust area (33a; 133a) of a first piston (33; 133) of the spool (32; 132) of the pressure control spool valve (30; 130), placing the displacement adjustment chamber (13; 113) of the pump (11; 111) in hydraulic connection with the outlet port (19; 119) of the pump (11; 111), by means of the pressure control spool valve (30; 130), and not with the tank of liquid (60; 160), so as to cause the pump (11; 111) to operate in the configuration of minimum displacement; and
- by means of a solenoid valve (55; 155), selectively placing a thrust area (34a; 134a) of a sec-

ond piston (34; 134) of the spool (32; 132), of opposite direction to the thrust area (33a; 133a) of the first piston (33; 133), in hydraulic connection with a tank of liquid (60; 160), so as to cause the pump (11; 111) to operate in the configuration of minimum displacement either in a first stable outlet pressure mode (HP; HP'), when the solenoid valve (55; 155) is closed, or in a second stable outlet pressure mode (LP; LP'), lower than the first stable outlet pressure mode, when the solenoid valve (55; 155) is open.

10. The adjustment method as claimed in claim 9, further comprising the step of:

- under the action of the hydraulic thrust that acts on the thrust area (33a; 133a) of the first piston (33; 133) of the spool (32; 132) of the pressure control spool valve (30; 130), placing the displacement adjustment chamber (13; 113) of the pump (11; 111) in hydraulic connection with both the outlet port (19; 119) of the pump (11; 111) and the tank of liquid (60; 160).

11. The adjustment method as claimed in claim 9 or 10, further comprising the step of:

- placing the thrust area (33a) of the first piston (33) of the spool (32) in hydraulic connection with the thrust area (34a) of the second piston (34) of the spool (32) through a pipe (37) made integral with the spool (32).

12. The adjustment method as claimed in claim 9 or 10, further comprising the step of:

- placing the thrust area (134a) of the second piston (134) of the spool (132) in hydraulic connection with the outlet port (119) of the pump (111), selectively.

13. The adjustment method as claimed in claim 12, in which said step of placing the thrust area (134a) of the second piston (134) of the spool (132) in hydraulic connection with a tank of liquid (160) is not implemented simultaneously with said step of placing the thrust area (134a) of the second piston (134) of the spool (132) in hydraulic connection with the outlet port (119) of the pump (111).

Patentansprüche

1. System zur Einstellung der Verdrängung (10; 110) für eine Pumpe mit variabler Verdrängung (11; 111), wobei das System umfasst

- eine Pumpe (11; 111) mit variabler Verdrängung, umfassend einen Rotor (15; 115), einen Stator (14; 114), der so ausgebildet ist, dass er so bewegt werden kann, dass die Exzentrizität zwischen seiner Achse (X) und der Drehachse (Y) des Rotors (15; 115) variiert wird, wodurch die Verdrängung der Pumpe (11; 111) variiert wird, eine Auslassöffnung (19; 119), eine Kammer (13; 113) zur Einstellung der Verdrängung, die so ausgebildet ist, dass ein in ihr herrschender Druck einen Schub auf den Stator (14; 114) erzeugt, der geeignet ist, den Stator (14; 114) zu bewegen, wodurch eine Änderung der Exzentrizität bewirkt wird, und ein elastisches Element (20; 120), das dem auf den Stator (14; 114) wirkenden Schub entgegenwirken kann,
- ein Druckregelschieberventil (30; 130), das einen äußeren Ventilkörper (31; 131), einen Schieber (32; 132), der in dem Ventilkörper (31; 131) gleiten kann und einen ersten Kolben (33; 133) und einen zweiten Kolben (34; 134) aufweist, und ein elastisches Rückstellelement (38; 138) umfasst, wobei der erste Kolben (33; 133) eine Druckfläche (33a; 133a) aufweist, die zusammen mit dem Ventilkörper (31; 131) eine erste Kammer (35; 135) des Druckregelschieberventils (30; 130) definiert und die mit der Auslassöffnung (19; 119) der Pumpe (11; 111) mittels eines ersten Auslasskanals (53; 153) hydraulisch verbunden ist, so dass ein hydraulischer Schub auf die Druckfläche (33a; 133a) des ersten Kolbens (33; 133) wirkt, wobei das elastische Rückstellelement (38; 138) ausgebildet ist, um dem hydraulischen Schub, der auf die Druckfläche (33a; 133a) des ersten Kolbens (33; 133) wirkt, entgegenzuwirken, wobei das Druckregelschieberventil (30; 130) ferner, das in dem äußeren Ventilkörper (31; 131) vorgesehen ist, ein erstes Einstellrohr (39; 139), das hydraulisch mit der Kammer (13; 113) zur Einstellung der Verdrängung verbunden ist, und ein zweites Einstellrohr (40; 140), das hydraulisch mit einem Flüssigkeitstank (60; 160) und wahlweise mittels des Schiebers (32; 132) mit dem ersten Einstellrohr (39; 139) verbunden ist, wobei die Kammer (13; 113) zur Einstellung der Verdrängung hydraulisch mit der Auslassöffnung (19; 119) der Pumpe (11; 111) über das Druckregelschieberventil (30; 130) verbunden ist,

wobei in einem ersten Zustand des Druckregelschieberventils (30; 130) der erste Kolben (33; 133) ausgebildet ist, um die hydraulische Verbindung zwischen dem ersten Einstellrohr (39; 139) und der ersten Kammer (35; 135) des Druckregelschieberventils (30; 130) zu schließen, und die hydraulische Verbindung zwischen dem ersten Einstellrohr (39; 139) und dem zweiten Einstellrohr (40; 140) offen zu lassen, und in einem zweiten Zustand des Druckregelschieberventils (30; 130) ist der erste Kolben (33; 133) ausgebildet, die hydraulische Verbindung zwischen dem ersten Einstellrohr (39; 139) und dem zweiten Einstellrohr (40; 140) zu schließen und die hydraulische Verbindung zwischen dem ersten Einstellrohr (39; 139) und der ersten Kammer (35; 135) des Druckregelschieberventils (30; 130) offen zu lassen, wobei der zweite Kolben (34; 134) des Druckregelschieberventils (30; 130) eine Druckfläche (34a; 134a) in entgegengesetzter Richtung zu der Druckfläche (33a; 133a) des ersten Kolbens (33; 133) aufweist,

dadurch gekennzeichnet, dass die Druckfläche (34a; 134a) des zweiten Kolbens (34; 134) wahlweise mit dem Flüssigkeitstank (60; 160) mittels eines Magnetventils (55; 155) hydraulisch verbunden ist, so dass ein hydraulischer Druck auf die Druckfläche (34a; 134a) des zweiten Kolbens (34; 134) entgegengesetzt zu dem hydraulischen Druck wirkt, der auf die Druckfläche (33a; 133a) des ersten Kolbens (33; 133) wirkt.

2. Einstellsystem (10; 110) nach Anspruch 1, bei dem der erste Kolben (33; 133) so ausgebildet ist, dass er in einem Zwischenzustand des Druckregelschieberventils (30; 130) die hydraulische Verbindung zwischen dem ersten Einstellrohr (39; 139) und dem zweiten Einstellrohr (40; 140) sowie zwischen dem ersten Einstellrohr (39; 139) und der ersten Kammer (35; 135) des Druckregelschieberventils (30; 130) nur teilweise blockiert.

3. Einstellsystem (10; 110) nach Anspruch 1 oder 2, in dem die Druckfläche (34a; 134a) des zweiten Kolbens (34; 134) des Schiebers (32; 132) eine kleinere Fläche aufweist als die Druckfläche (33a; 133a) des ersten Kolbens (33; 133) des Schiebers (32; 132).

4. Einstellsystem (10; 110) nach einem der vorhergehenden Ansprüche, bei dem der Schieber (32; 132) einen einzigen Unterschied in dem Querschnitt zwischen dem ersten Kolben (33; 133) und dem zweiten Kolben (34; 134) umfasst.

5. Einstellsystem (10) nach einem der vorhergehenden Ansprüche, bei dem der Schieber (32) ein mit ihm integral ausgebildetem Rohr (37) umfasst, das die Druckfläche (33a) des ersten Kolbens (33) des Schiebers (32) mit der Druckfläche (34a) des zweiten Kolbens (34) des Schiebers (32) hydraulisch verbindet.

6. Einstellsystem (10) nach Anspruch 1, bei dem das Magnetventil (55), das wahlweise die Druckfläche (34a) des zweiten Kolbens (34) mit dem Flüssigkeitstank (60) hydraulisch verbindet, ein 2/2-Ventil (55) ist.

7. Einstellsystem (110) nach einem der Ansprüche 1 bis 4, bei dem die Druckfläche (134a) des zweiten Kolbens (134) wahlweise über das Magnetventil (155) mit dem Flüssigkeitstank (160) oder alternativ mit der Auslassöffnung (119) der Pumpe (111) hydraulisch verbunden ist.

8. Einstellsystem (110) nach Anspruch 7, bei dem das Magnetventil (155) ein 3/2-Ventil ist.

9. Verfahren zum Einstellen der Verdrängung einer Pumpe mit variabler Verdrängung (11; 111), die eine Kammer (13; 113) zur Einstellung der Verdrängung umfasst, mittels eines Einstellsystem (10; 110), das ein Druckregelschieberventil (30; 130) umfasst, wobei das Verfahren die Schritte umfasst:

- Platzieren der Kammer (13; 113) zur Einstellung der Verdrängung der Pumpe (11; 111), die über das Druckregelschieberventil (30; 130) mit einem Flüssigkeitstank (60; 160) und nicht mit einer Auslassöffnung (19; 119) der Pumpe (11; 111) hydraulisch verbunden ist, um die Pumpe (11; 111) in der Konfiguration maximaler Verdrängung zu betreiben;
- unter der Wirkung eines hydraulischen Schubs, der auf eine Druckfläche (33a; 133a) eines ersten Kolbens (33; 133) des Schiebers (32; 132) des Druckregelschieberventils (30; 130) einwirkt, die Platzierung der Kammer (13; 113) zur Einstellung der Verdrängung der Pumpe (11; 111) mittels des Druckregelschieberventils (30; 130) in hydraulischer Verbindung mit der Auslassöffnung (19; 119) der Pumpe (11; 111) und nicht mit dem Flüssigkeitstank (60; 160), um die Pumpe (11; 111) in der Konfiguration der minimalen Verdrängung zu betreiben;

und

- wahlweise Platzierung einer Druckfläche (34a; 134a) eines zweiten Kolbens (34; 134) des Schiebers (32; 132) in entgegengesetzter Richtung zur Druckfläche (33a; 133a) des ersten Kolbens (33; 133) mittels eines Magnetventils (55; 155) in hydraulischer Verbindung mit einem Flüssigkeitstank (60; 160), um die Pumpe (11; 111) in der Konfiguration der minimalen Verlagerung entweder in einem ersten Modus mit stabilem Ausgangsdruck (HP; HP'), wenn das Magnetventil (55; 155) geschlossen ist, oder in einem zweiten Modus mit stabilem Ausgangsdruck (LP; LP'), der niedriger ist als der erste Modus mit stabilem Ausgangsdruck, wenn das Magnetventil (55; 155) geöffnet ist, zu betreiben.

10. Einstellverfahren nach Anspruch 9, ferner den

Schritt umfassend:

- unter der Wirkung des hydraulischen Schubs, der auf die Druckfläche (33a; 133a) des ersten Kolbens (33; 133) des Schiebers (32; 132) des Druckregelschieberventils (30; 130) wirkt, Platzierung der Kammer (13; 113) zur Einstellung der Verdrängung der Pumpe (11; 111) sowohl mit der Auslassöffnung (19; 119) der Pumpe (11; 111) als auch mit dem Flüssigkeitstank (60; 160) in hydraulischer Verbindung.

11. Einstellverfahren nach Anspruch 9 oder 10, ferner den Schritt umfassend:

- Platzierung der Druckfläche (33a) des ersten Kolbens (33) des Schiebers (32) mit der Druckfläche (34a) des zweiten Kolbens (34) des Schiebers (32) über ein mit dem Schieber (32) integral ausgebildetem Rohr (37) in hydraulischer Verbindung.

12. Einstellverfahren nach Anspruch 9 oder 10, ferner den Schritt umfassend:

- Platzierung der Druckfläche (134a) des zweiten Kolbens (134) des Schiebers (132) wahlweise in hydraulischer Verbindung mit der Auslassöffnung (119) der Pumpe (111).

13. Einstellverfahren nach Anspruch 12, bei dem der Schritt, die Druckfläche (134a) des zweiten Kolbens (134) des Schiebers (132) in hydraulischer Verbindung mit einem Flüssigkeitstank (160) zu platzieren, nicht gleichzeitig mit dem Schritt ausgeführt wird, die Druckfläche (134a) des zweiten Kolbens (134) des Schiebers (132) in hydraulischer Verbindung mit der Auslassöffnung (119) der Pumpe (111) zu platzieren.

Revendications

1. Système de réglage de cylindrée (10; 110) pour une pompe à cylindrée variable (11; 111), ledit système comprenant

- une pompe à cylindrée variable (11; 111) comprenant un rotor (15; 115), un stator (14; 114) configuré pour être mis en mouvement de manière à faire varier l'excentricité entre son axe (X) et l'axe de rotation (Y) du rotor (15 ; 115), faisant ainsi varier la cylindrée de la pompe (11 ; 111), un orifice de sortie (19 ; 119), une chambre de réglage de cylindrée (13 ; 113), configurée de sorte qu'une pression régnant à l'intérieur de celle-ci génère une poussée sur le stator (14 ; 114) capable de mettre en mouvement le stator (14 ; 114), entraînant une modification de ladite excentricité, et un élément élastique (20 ; 120) capable de contrer ladite poussée agissant sur le stator (14 ; 114),

- un distributeur à tiroir de régulation de pression (30 ; 130) comprenant un corps de distributeur externe (31 ; 131), un tiroir (32 ; 132) capable de coulisser dans ledit corps de distributeur (31 ; 131) et comportant un premier piston (33 ; 133) et un deuxième piston (34 ; 134), et un élément de rappel élastique (38 ; 138), ledit premier piston (33 ; 133) ayant une zone de poussée (33a ; 133a), qui définit, conjointement avec le corps de distributeur (31 ; 131), une première chambre (35 ; 135) du distributeur à tiroir de régulation de pression (30 ; 130) et qui est reliée hydrauliquement à l'orifice de sortie (19 ; 119) de la pompe (11 ; 111) au moyen d'un premier conduit de sortie (53 ; 153), de sorte qu'une poussée hydraulique agit sur ladite zone de poussée (33a ; 133a) du premier piston (33 ; 133), ledit élément de rappel élastique (38 ; 138) étant configuré pour s'opposer à ladite poussée hydraulique agissant sur la zone de poussée (33a ; 133a) du premier piston (33 ; 133), ledit distributeur à tiroir de régulation de pression (30 ; 130) comprenant en outre, prévue dans le corps de distributeur externe (31 ; 131), un premier tuyau de réglage (39 ; 139), relié hydrauliquement à la chambre de réglage de cylindrée (13 ; 113), et un deuxième tuyau de réglage (40 ; 140), relié hydrauliquement à un réservoir de liquide (60 ; 160) et sélectivement, au moyen dudit tiroir (32 ; 132), au premier tuyau de réglage (39 ; 139),

dans lequel ladite chambre de réglage de cylindrée (13 ; 113) est reliée hydrauliquement à l'orifice de sortie (19 ; 119) de la pompe (11 ; 111) par l'intermédiaire dudit distributeur à tiroir de régulation de pression (30 ; 130), sélectivement, moyennant quoi, dans un premier état du distributeur à tiroir de régulation de pression (30 ; 130), le premier piston (33 ; 133) est configuré pour fermer la liaison hydraulique entre le premier tuyau de réglage (39 ; 139) et la première chambre (35 ; 135) du distributeur à tiroir de régulation de pression (30 ; 130),

et de laisser ouverte la liaison hydraulique entre le premier tuyau de réglage (39 ; 139) et le deuxième tuyau de réglage (40 ; 140), et dans un deuxième état du distributeur à tiroir de régulation de pression (30 ; 130), le premier piston (33 ; 133) est configuré pour fermer la liaison hydraulique entre le premier tuyau de réglage (39 ; 139) et le deuxième tuyau de réglage (40 ; 140), et pour laisser ouverte la liaison hydraulique entre le premier tuyau de réglage (39 ; 139) et la première chambre (35 ; 135) du distributeur

à tiroir de régulation de pression (30 ; 130), dans lequel ledit deuxième piston (34 ; 134) du distributeur à tiroir de régulation de pression (30 ; 130) a une zone de poussée (34a; 134a) de direction opposée à la zone de poussée (33a; 133a) du premier piston (33 ; 133),
caractérisé en ce que ladite zone de poussée (34a; 134a) dudit deuxième piston (34 ; 134) est reliée hydrauliquement, sélectivement, au réservoir de liquide (60 ; 160), au moyen d'une électrovanne (55 ; 155), de sorte qu'une poussée hydraulique agit sur ladite zone de poussée (34a ; 134a) du deuxième piston (34 ; 134) en opposition à ladite poussée hydraulique agissant sur la zone de poussée (33a ; 133a) du premier piston (33 ; 133).

2. Système de réglage (10 ; 110) selon la revendication 1, dans lequel, dans un état intermédiaire du distributeur à tiroir de régulation de pression (30 ; 130), le premier piston (33 ; 133) est configuré pour n'obstruer que partiellement la liaison hydraulique entre le premier tuyau de réglage (39 ; 139) et le deuxième tuyau de réglage (40 ; 140) et entre le premier tuyau de réglage (39 ; 139) et la première chambre (35 ; 135) du distributeur à tiroir de régulation de pression (30 ; 130).

3. Système de réglage (10 ; 110) selon la revendication 1 ou 2, dans lequel la zone de poussée (34a ; 134a) du deuxième piston (34 ; 134) du tiroir (32 ; 132) présente une superficie plus petite que la zone de poussée (33a ; 133a) du premier piston (33 ; 133) du tiroir (32 ; 132).

4. Système de réglage (10 ; 110) selon l'une quelconque des revendications précédentes, dans lequel ledit tiroir (32 ; 132) comprend une seule différence de section entre le premier piston (33 ; 133) et le deuxième piston (34 ; 134).

5. Système de réglage (10) selon l'une quelconque des revendications précédentes, dans lequel le tiroir (32) comprend un tuyau (37) rendu solidaire de celui-ci et reliant hydrauliquement la zone de poussée (33a) du premier piston (33) du tiroir (32) à la zone de poussée (34a) du deuxième piston (34) du tiroir (32).

6. Système de réglage (10) selon la revendication 1, dans lequel l'électrovanne (55) qui relie hydrauliquement, sélectivement, la zone de poussée (34a) du deuxième piston (34) au réservoir de liquide (60) est une électrovanne 2/2 (55).

7. Système de réglage (110) selon l'une quelconque des revendications 1 à 4, dans lequel la zone de poussée (134a) du deuxième piston (134) est reliée hydrauliquement, sélectivement, au moyen de ladite électrovanne (155), au réservoir de liquide (160) ou à l'orifice de sortie (119) de la pompe (111), alternativement.

8. Système de réglage (110) selon la revendication 7, dans lequel l'électrovanne (155) est une électrovanne 3/2.

9. Procédé de réglage de la cylindrée d'une pompe à cylindrée variable (11 ; 111) comprenant une chambre de réglage de cylindrée (13 ; 113), au moyen d'un système de réglage (10; 110) comprenant un distributeur à tiroir de régulation de pression (30 ; 130), ledit procédé comprenant les étapes de :

- placement de la chambre de réglage de cylindrée (13 ; 113) de la pompe (11 ; 111) en liaison hydraulique avec un réservoir de liquide (60 ; 160), au moyen du distributeur à tiroir de régulation de pression (30 ; 130), et non pas avec un orifice de sortie (19 ; 119) de la pompe (11 ; 111), de façon à amener la pompe (11 ; 111) à fonctionner dans la configuration de cylindrée maximale ;
- sous l'action d'une poussée hydraulique qui agit sur une zone de poussée (33a ; 133a) d'un premier piston (33 ; 133) du tiroir (32 ; 132) du distributeur à tiroir de régulation de pression (30 ; 130), placement de la chambre de réglage de cylindrée (13 ; 113) de la pompe (11 ; 111) en liaison hydraulique avec l'orifice de sortie (19 ; 119) de la pompe (11 ; 111), au moyen du distributeur à tiroir de régulation de pression (30 ; 130), et non avec le réservoir de liquide (60 ; 160), de façon à amener la pompe (11 ; 111) à fonctionner dans la configuration de cylindrée minimale ; et
- au moyen d'une électrovanne (55 ; 155), placement sélectif d'une zone de poussée (34a ; 134a) d'un deuxième piston (34 ; 134) du tiroir (32 ; 132), de direction opposée à la zone de poussée (33a ; 133a) du premier piston (33 ; 133), en liaison hydraulique avec un réservoir de liquide (60 ; 160), de façon à amener la pompe (11 ; 111) à fonctionner dans la configuration de cylindrée minimale soit dans un premier mode de pression de sortie stable (HP ; HP'), lorsque l'électrovanne (55 ; 155) est fermée, soit dans un deuxième mode de pression de sortie stable (LP ; LP'), inférieur au premier mode de pression de sortie stable, lorsque l'électrovanne (55 ; 155) est ouverte.

10. Procédé de réglage selon la revendication 9, comprenant en outre l'étape de :

- sous l'action de la poussée hydraulique qui agit sur la zone de poussée (33a ; 133a) du premier piston (33 ; 133) du tiroir (32 ; 132) du distributeur à tiroir de régulation de pression (30 ; 130), placement de la chambre de réglage de cylindrée (13 ; 113) de la pompe (11 ; 111) en liaison hydraulique à la fois avec l'orifice de sortie (19 ; 119) de la pompe (11 ; 111) et le réservoir de liquide (60 ; 160) .

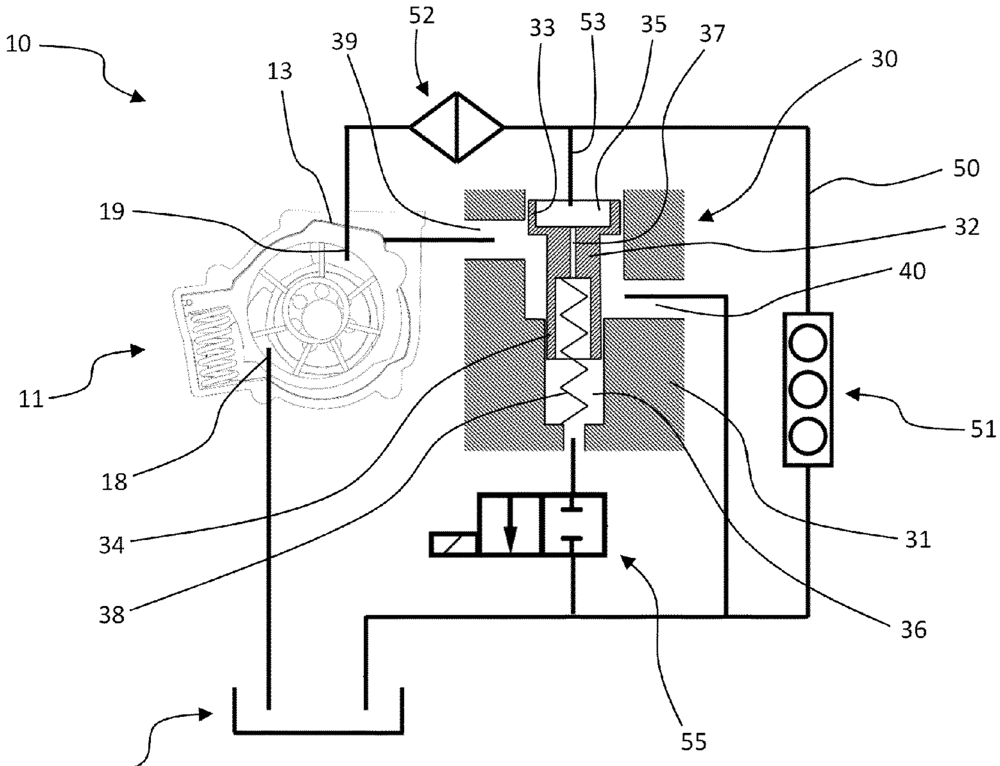
11. Procédé de réglage selon la revendication 9 ou 10, comprenant en outre l'étape de :

- placement de la zone de poussée (33a) du premier piston (33) du tiroir (32) en liaison hydraulique avec la zone de poussée (34a) du deuxième piston (34) du tiroir (32) par l'intermédiaire d'un tuyau (37) rendu solidaire du tiroir (32).

12. Procédé de réglage selon la revendication 9 ou 10, comprenant en outre l'étape de :

- placement sélectif de la zone de poussée (134a) du deuxième piston (134) du tiroir (132) en liaison hydraulique avec l'orifice de sortie (119) de la pompe (111).

13. Procédé de réglage selon la revendication 12, dans lequel ladite étape de placement en liaison hydraulique de la zone de poussée (134a) du deuxième piston (134) du tiroir (132) avec un réservoir de liquide (160) n'est pas mise en œuvre simultanément avec ladite étape de placement en liaison hydraulique de la zone de poussée (134a) du deuxième piston (134) du tiroir (132) avec l'orifice de sortie (119) de la pompe (111).


10
11
13
19
39
52
33
53
35
37
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32
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36
55
60
18
34
38

Fig. 1

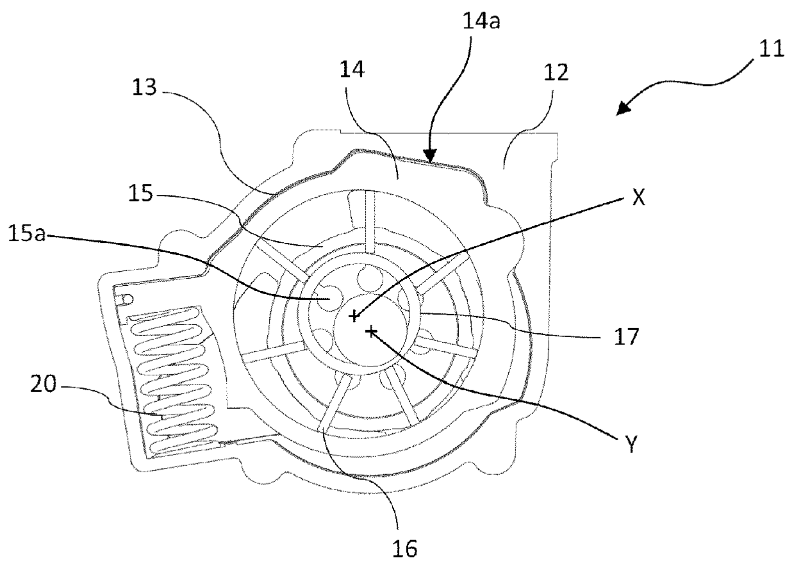
14a
11
13
14
12
15
X
15a
17
20
Y
16

Fig. 2

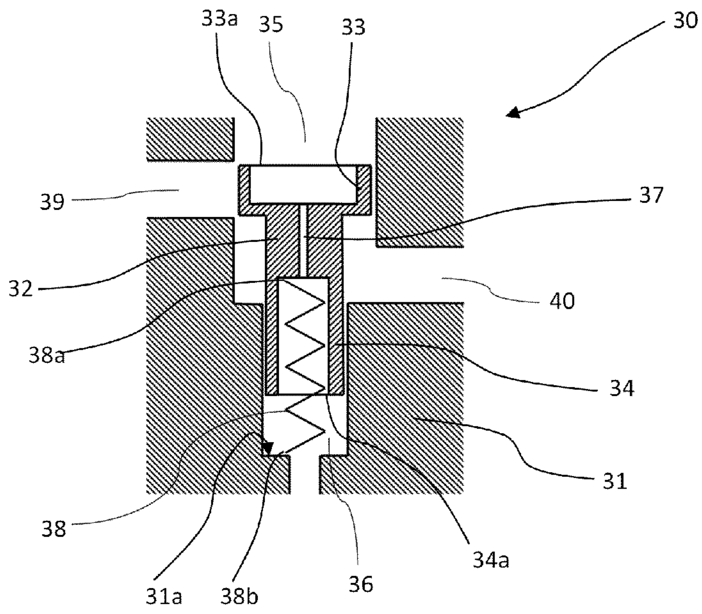

Fig. 3

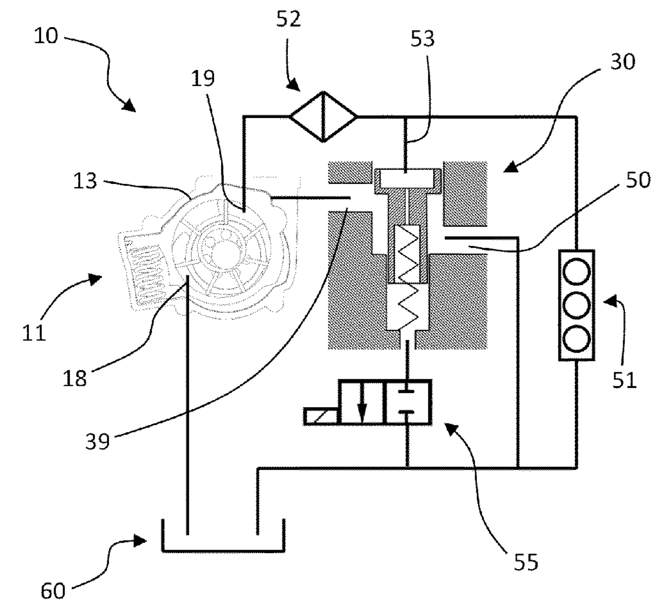

Fig. 4a

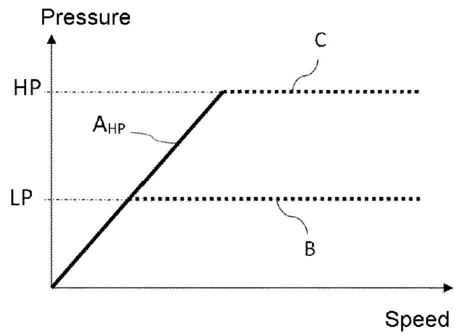

Fig. 4b

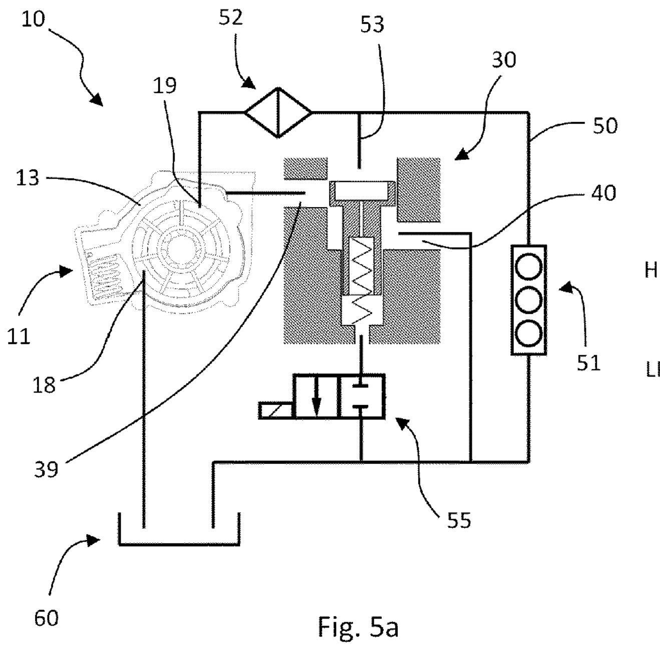

Fig. 5a

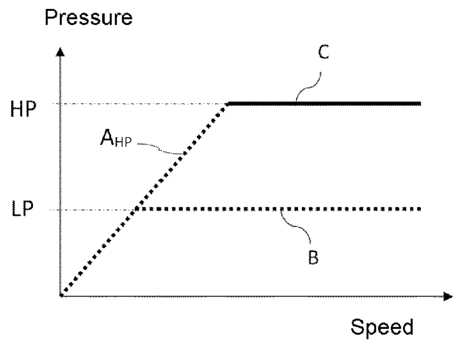

Fig. 5b

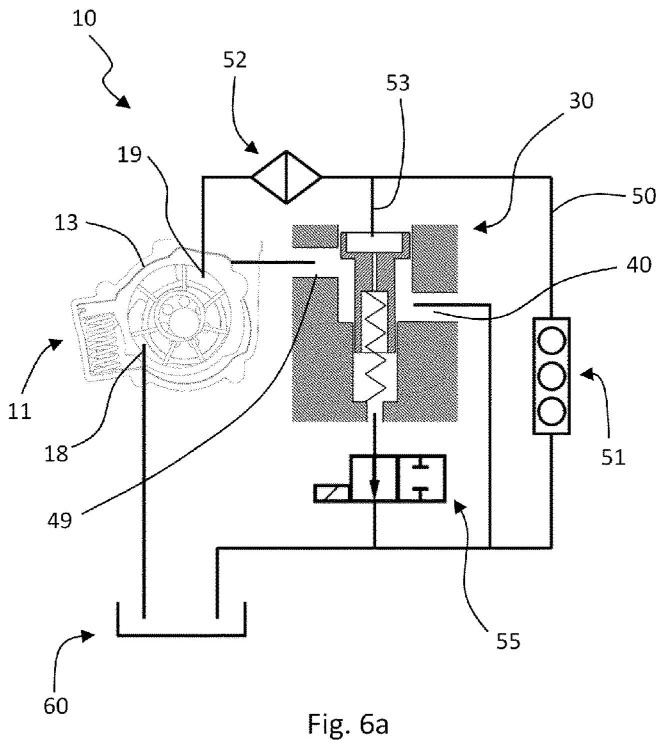

Fig. 6a

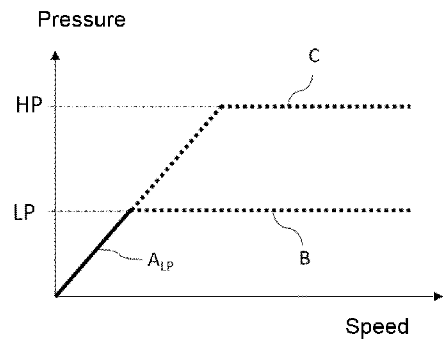

Fig. 6b

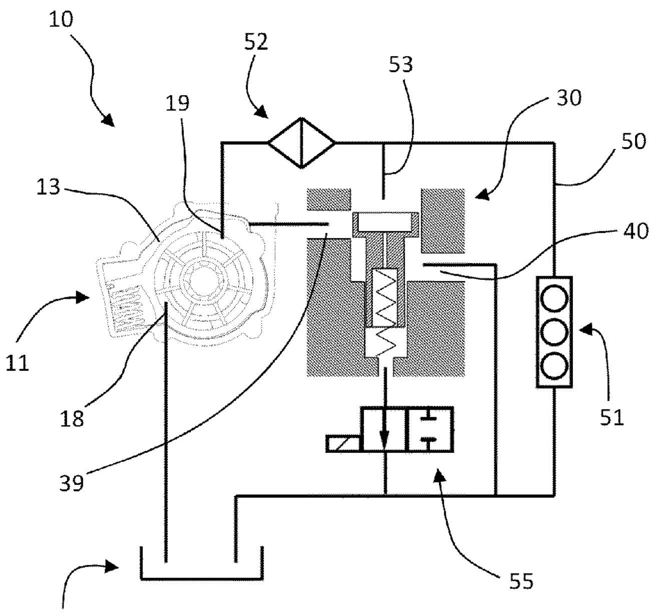

Fig. 7a

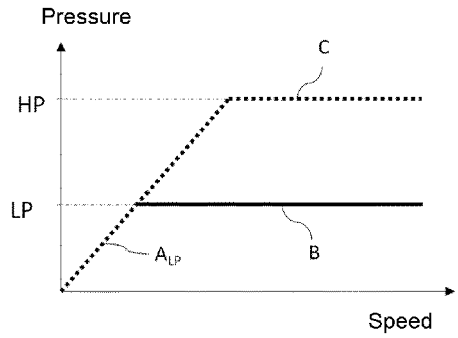

Fig. 7b

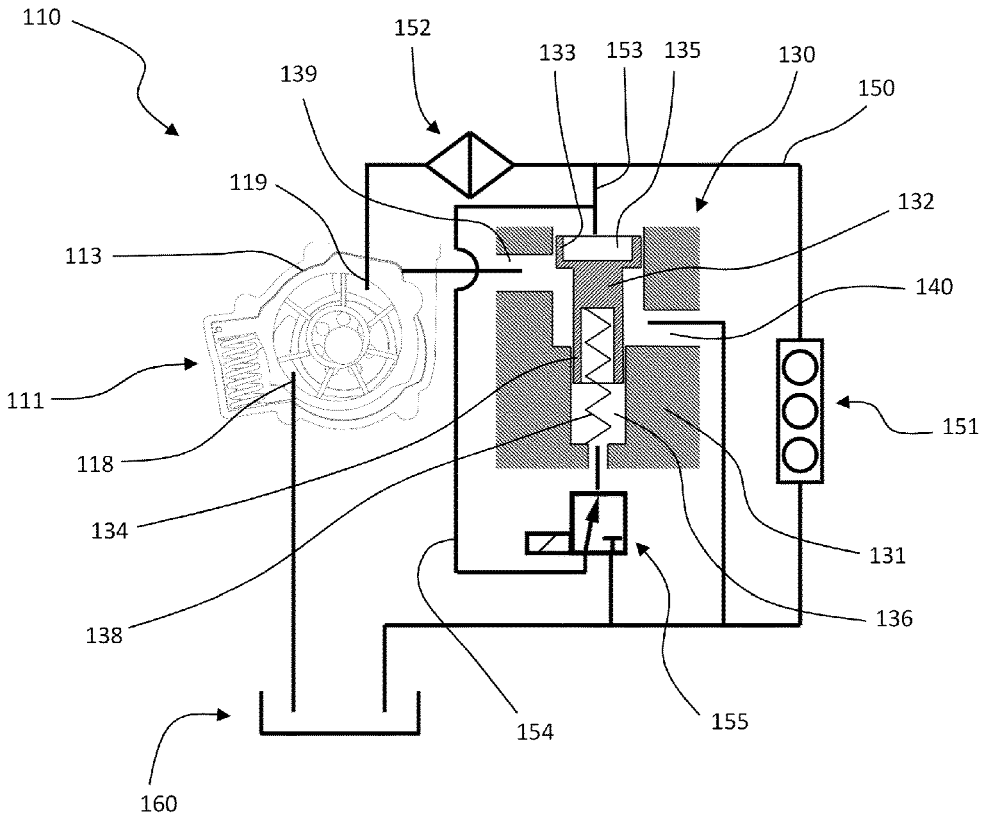

Fig. 8

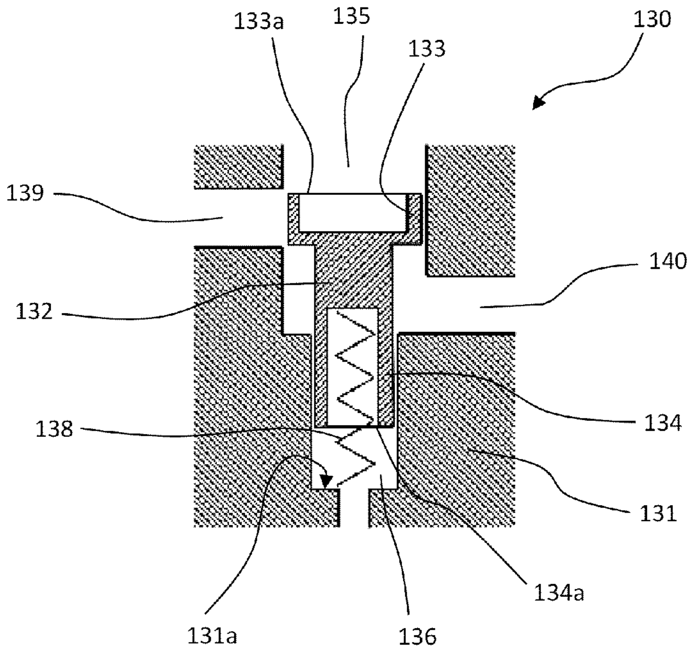

Fig. 9

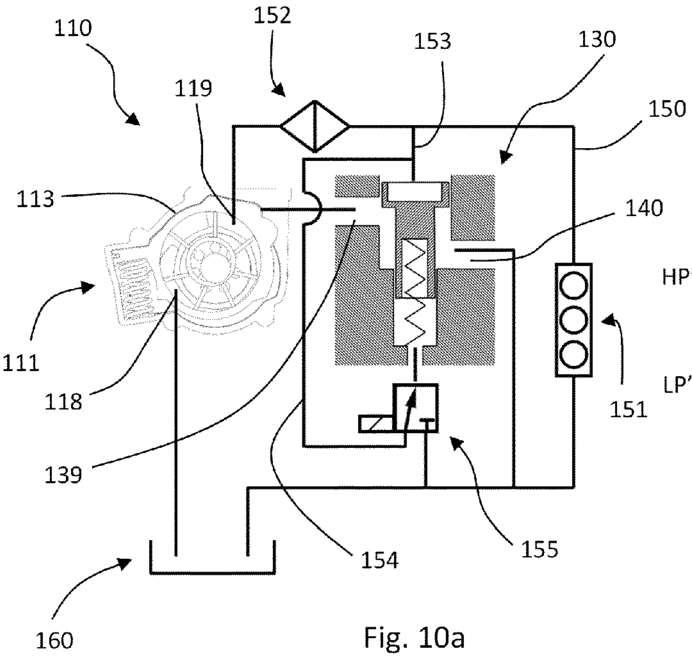

Fig. 10a

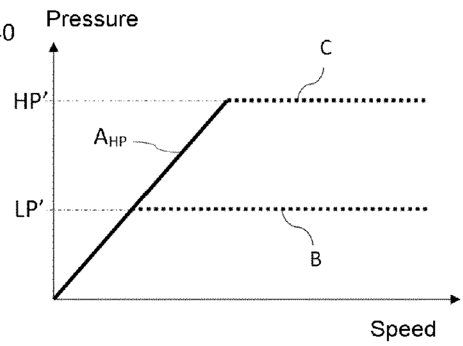

Fig.10b

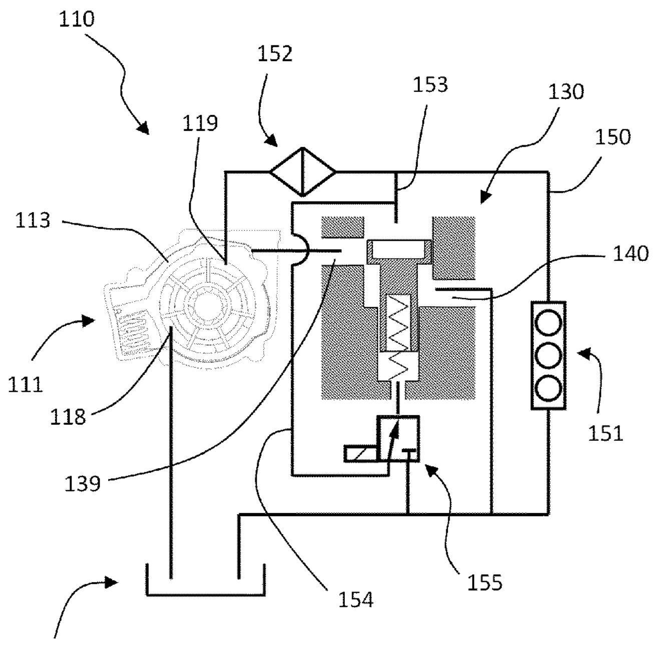

Fig. 11a

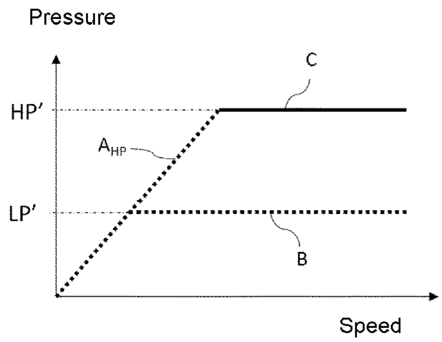

Fig. 11b

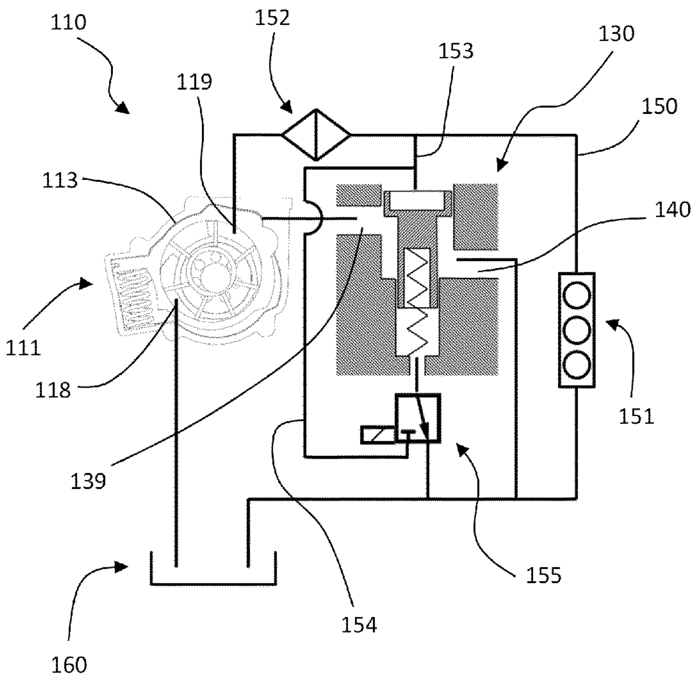

Fig. 12a

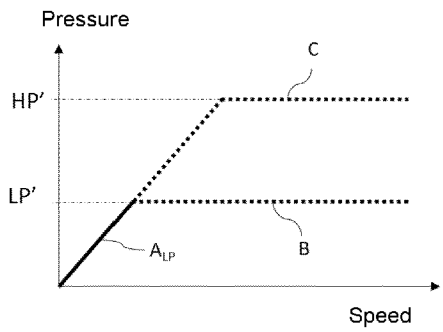

Fig. 12b

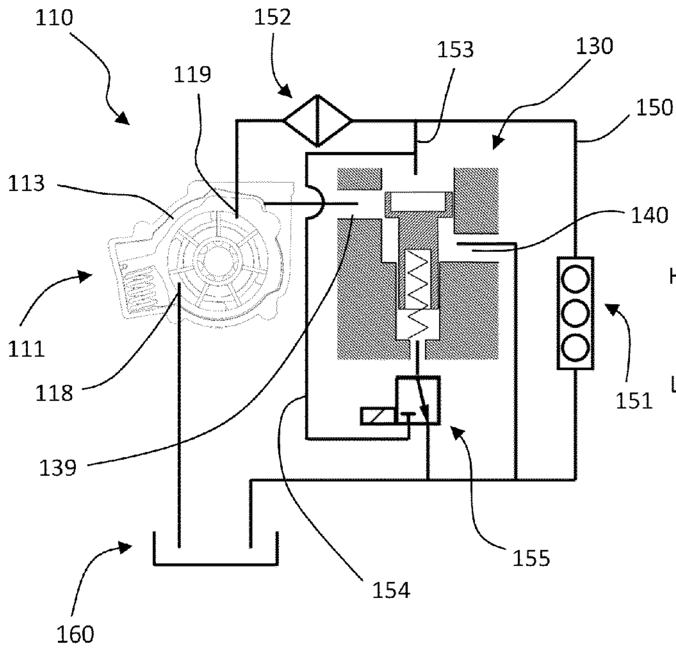

Fig. 13a

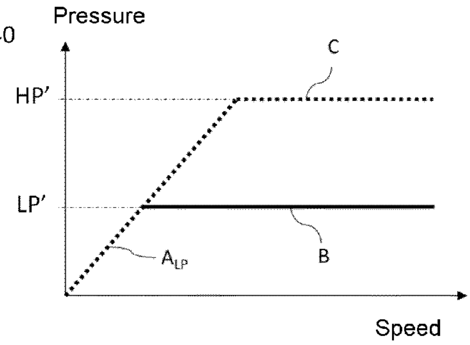

Fig. 13b

REFERENCES CITED IN THE DESCRIPTION

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