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(54) **Displacement control valve for variable displacement compressor**

Regelventil für einen Kompressor mit veränderlicher Verdrängung

Soupape de contrôle pour compresseur à capacité variable

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a displacement control valve employed for a variable displacement compressor, which valve supplies refrigerant from a discharge pressure zone to a control pressure chamber and discharges refrigerant from the control pressure chamber to a suction pressure zone, thereby controlling the pressure in the control pressure chamber, and changing the displacement of the compressor, accordingly.

[0002] In a variable displacement compressor having a control pressure chamber for accommodating a tiltable swash plate, the inclination angle of the swash plate is reduced as the pressure in the control pressure chamber is increased, and increased as the control chamber pressure is reduced. When the inclination angle of the swash plate is reduced, the stroke of pistons is reduced, which decreases the displacement. When the inclination angle of the swash plate is increased, the piston stroke is increased, which increases the displacement.

[0003] EP1 081 378 represents the closest prior art according to which the preamble of claim 1 in drafted.

[0004] Japanese Laid-Open Patent Publication No. 2000-249050 discloses a displacement control valve having a first valve body and a second valve body. The first valve body selectively opens and closes a supply passage for supplying refrigerant from a discharge pressure zone to a crank chamber (control pressure chamber). The second valve body selectively opens and closes a discharge passage for discharging refrigerant from the crank chamber to a suction pressure zone. The displacement control valve includes a single solenoid and a pressure sensing member senses suction pressure and actuates the first valve body. The solenoid includes a plunger. The pressure sensing member is coupled to a first rod, which is fixed to the plunger. The first valve body receives urging force from the pressure sensing member in a direction opening a first valve hole, which is a part of the supply passage. The second valve body receives discharge pressure in a direction closing a second valve hole, which is a part of the discharge passage. A second rod is fixed to the first valve body. When the first valve body moves from a position for opening the first valve hole toward a position for closing the first valve hole, the second rod is moved in a direction to move the second valve body from a position closer to a position for closing the second valve hole toward a position for opening the second valve hole. The first valve hole is formed in a movable valve seat. The first valve body, the movable valve seat, and the second rod are movable with the first valve hole closed.

[0005] The displacement control valve is configured such that a state in which the first valve body is in the position for opening the first valve hole does not concurrently occurs with a state in which the second valve body is in the position for opening the second valve hole (refer to Fig. 4 of the above mentioned publication). That is, when the second valve body opens the second valve hole, the first valve body closes the first valve hole, and when the first valve body opens the first valve hole, the second valve body closes the second valve hole. A configuration in which the first valve hole and the second valve hole are not simultaneously opened, the suction pressure is stabilized at a target suction pressure when the electromagnetic force of the solenoid is adjusted to correspond to the target suction pressure. That is, the target suction pressure is set accurately.

[0006] In the displacement control valve disclosed in the above mentioned publication, when the first valve body closes the first valve hole, the second valve body opens the second valve hole, and when the second valve body closes the second valve hole, the first valve body opens the first valve hole. That is, a state in which the first valve body is located in the position for closing the first valve hole and the second valve body is located in the position for closing the second valve hole occurs only when the second rod is at a specific position (a position of the second rod when the first valve body contacts the movable valve seat, and the movable valve seat contacts a valve seat defining portion). However, due to dimensional errors and assembly errors of the components of the displacement control valve, it is difficult to configure the valve such that, only when the second rod is at the specific position, the first valve body closes the first valve hole and the second valve body closes the second valve hole. That is, it is possible that the first and second valve open simultaneously. When opening simultaneously, the first and second valve holes increase the flow rate of refrigerant that wastefully flows from the discharge pressure zone to the suction pressure zone through the control pressure chamber. This reduces the efficiency of the compressor.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an objective of the present invention to provide a displacement control valve for a variable displacement compressor, which valve prevents a valve hole that is a part of a supply passage from opening concurrently with a valve hole that is a part of a discharge passage.

[0008] To achieve the above-mentioned objective, the present invention provides a displacement control valve for a variable displacement compressor. The compressor has a discharge pressure zone exposed to the pressure of refrigerant that has been compressed by the compressor; a suction pressure zone exposed to the pressure of refrigerant that is drawn into the compressor; a control pressure chamber; a supply passage that connects the discharge pressure zone to the control pressure chamber; and a discharge passage that connects the suction pressure zone to the control pressure chamber. The control valve adjusts the pressure of the control pressure chamber by supplying refrigerant in the discharge pressure zone to the control pressure chamber through the supply passage and discharging refrigerant in the control pressure chamber to the suction pressure zone through the discharge passage, thereby controlling the displacement of the compressor. The control valve includes a first valve hole forming a part of the supply passage; a first valve body that selectively opens and closes the first valve hole; a second valve hole forming a part of the discharge passage; a second valve body that selectively opens and closes the second valve hole; and a reciprocating body that is capable of being displaced and reciprocated. Displacement of the reciprocating body is transmitted to each of the first and second valve bodies so that each valve body opens or closes the corresponding valve hole. When the reciprocating body is within a predetermined displacement range, a double closing state occurs, in which the first valve body closes the first valve hole and the second valve hole closes the second valve hole. When the reciprocating body is out of the displacement range, a single closing state occurs, in which only one of the first valve body and the second valve body closes the corresponding one of the valve holes.

[0009] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a side cross-sectional view illustrating an entire compressor according a first embodiment of the present invention;
Fig. 2(a) is a cross-sectional view illustrating a displacement control valve incorporated in the compressor shown in Fig. 1;
Figs. 2(b) and 2(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 2(a);
Figs. 3(a) to 3(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 2(a);
Fig. 4(a) is a cross-sectional view illustrating a displacement control valve according to a second embodiment of the present invention;
Fig. 4(b) is an enlarged partial cross-sectional view of the control valve shown in Fig. 4(a);
Fig. 5(a) is a cross-sectional view illustrating a displacement control valve according to a third embodiment;
Figs. 5(b) and 5(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 5(a);
Figs. 6(a) to 6(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 5(a);
Fig. 7 is an enlarged partial cross-sectional view illustrating a control valve according to a fourth embodiment;
Figs. 8(a) and 8(b) are enlarged partial cross-sectional views illustrating a control valve according to a fifth embodiment;
Fig. 9(a) is a cross-sectional view illustrating a displacement control valve according to a sixth embodiment;
Figs. 9(b) and 9(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 9(a);
Figs. 10(a) to 10(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 9(a);
Fig. 11(a) is a cross-sectional view illustrating a displacement control valve according to a seventh embodiment;
Fig. 11(b) is an enlarged partial cross-sectional view of Fig. 11(a);
Fig. 12(a) is a cross-sectional view illustrating a displacement control valve according to an eighth embodiment;
Figs. 12(b) and 12(c) are enlarged partial cross-sectional views of Fig. 12(a);
Figs. 13(a) to 13(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 12(a);
Fig. 14(a) is a cross-sectional view illustrating a displacement control valve according to a ninth embodiment;
Fig. 14(b) is an enlarged partial cross-sectional view of Fig. 14(a);
Fig. 15(a) is a cross-sectional view illustrating a displacement control valve according to a tenth embodiment;
Fig. 15(b) is an enlarged partial cross-sectional view of Fig. 15(a);
Fig. 16(a) is a cross-sectional view illustrating a displacement control valve according to an eleventh embodiment;
Figs. 16(b) and 16(c) are enlarged partial cross-sectional views of Fig. 16(a);
Figs. 17(a), 17(b), and 17(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 16(a);
Fig. 18(a) is a cross-sectional view illustrating a displacement control valve according to a twelfth embodiment;
Fig. 18(b) is an enlarged partial cross-sectional view of Fig. 18(a);
Fig. 19(a) is a cross-sectional view illustrating a displacement control valve according to a thirteenth embodiment;
Figs. 19(b) and 19(c) are enlarged partial cross-sectional views of Fig. 19(a);
Figs. 20(a), 20(b), and 20(c) are enlarged partial cross-sectional views of the control valve shown in Fig. 19(a);
Fig. 21 is an enlarged cross-sectional view illustrating a fourteenth embodiment;
Fig. 22(a) is a cross-sectional view illustrating a displacement control valve according to a fifteenth embodiment;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] A first embodiment of the present invention will now be described with reference to Figs. 1 to 3(c).

[0012] As shown in Fig. 1, a front housing member 12 is secured to the front end of a cylinder block 11. A rear housing member 13 is secured to the rear end of the cylinder block 11 with a valve plate 14, valve flap plates 15, 16, and a retainer plate 17 arranged in between. The cylinder block 11, the front housing member 12, and the rear housing member 13 form a housing of the compressor 10.

[0013] The front housing member 12 and the cylinder block 11 define a control pressure chamber 121. The front housing member 12 and the cylinder block 11 rotatably support a rotary shaft 18 with radial bearings 19, 20. The rotary shaft 18 projects from the control pressure chamber 121 to the outside, and receives power from a vehicle engine E, which is an external power source, through an electromagnetic clutch (not shown).

[0014] A rotary support 21 is fixed to the rotary shaft 18, and a swash plate 22 is supported on the rotary shaft 18. The swash plate 22 is permitted to incline with respect to and slide along the rotary shaft 18. A pair of guide holes 211 are formed in the rotary support 21, and a pair of guide pins 23 are formed on the swash plate 22. The guide pins 23 are slidably fitted in the guide holes 211. The engagement of the guide pins 23 with the guide holes 211 allows the swash plate 22 to be tiltable with respect to the rotary shaft 18 and rotatable together with the rotary shaft 18. The guide holes 211 slidably guide the guide pins 23, and the rotary shaft 18 slidably supports the swash plate 22. These actions permit the swash plate 22 to be inclined.

[0015] When the center of the swash plate 22 moves toward the rotary support 21, the inclination of the swash plate 22 increases. When contacting the swash plate 22, the rotary support 21 determines the maximum inclination of the swash plate 22. When in a position indicated by solid lines in Fig. 1, the swash plate 22 is at the maximum inclination position. When in a position indicated by chain lines, the swash plate 22 is at the minimum inclination position. The minimum inclination angle of the swash plate 22 is slightly greater than zero degrees.

[0016] Cylinder bores 111 extend through the cylinder block 11. Each cylinder bore 111 accommodates a piston 24. The rotation of the swash plate 22 is converted to reciprocation of the pistons 24 by means of shoes 25. Thus, each piston 24 reciprocates in the corresponding cylinder bore 111.

[0017] A suction chamber 131 and a discharge chamber 132 are defined in the rear housing member 13. Suction ports 141 are formed in a valve plate 14 and a valve flap plate 16. Discharge ports 142 are formed in the valve plate 14 and a valve flap plate 15. Suction valve flaps 151 are formed on the valve flap plate 15, and discharge valve flaps 161 are formed on the valve flap plate 16. As each piston 24 moves from the top dead center to the bottom dead center (from the right side to the left side in Fig. 1), refrigerant in the suction chamber 131, which is a suction pressure zone, is drawn into the associated cylinder bore 111 through the corresponding suction port 141 while flexing the suction valve flap 151. When each piston 24 moves from the bottom dead center to the top dead center (from the left side to the right side in Fig. 1), gaseous refrigerant in the corresponding cylinder bore 111 is discharged to the discharge chamber 132, which is a discharge pressure zone, through the corresponding discharge port 142 while flexing the discharge valve flap 161. The retainer plate 17 includes retainers 171, which correspond to the discharge valves 161. Each retainer 171 restricts the opening degree of the corresponding discharge valve flap 161.

[0018] A suction passage 26 for guiding refrigerant into the suction chamber 131 and a discharge passage 27 for discharging refrigerant from the discharge chamber 132 are connected to each other by an external refrigerant circuit

28. A heat exchanger 29 for drawing heat from refrigerant, an expansion valve 30, and a heat exchanger 31 for transferring the ambient heat to refrigerant are located on the external refrigerant circuit 28. The expansion valve 30 is an automatic thermal expansion valve that controls the flow rate of refrigerant in accordance with fluctuations of gas temperature at the outlet of the heat exchanger 31. A constriction 281 is provided in a part of the external refrigerant circuit (hereinafter referred to as circuit sections 28A, 28B) that is downstream of the discharge passage 27 and upstream of the heat exchanger 29. The circuit section 28A is located upstream of the constriction 281, and the circuit section 28B is located downstream of the constriction 281.

[0019] An electromagnetic displacement control valve 32 is installed in the rear housing member 13.

[0020] As shown in Fig. 2(a), the displacement control valve 32 includes a solenoid 41. A fixed iron core 42 of the solenoid 41 attracts a movable iron core 44 based on excitation by current supplied to a coil 43. The solenoid 41 is subjected to current supply control (duty ratio control in this embodiment) executed by a control computer C (see Fig. 1). A transmission rod 45 is fixed to the movable iron core 44.

[0021] A valve housing 33, which forms the displacement control valve 32, has a valve hole forming wall 34 and a valve seat 35. A first valve hole 36 is formed in the valve hole forming wall 34, and a second valve hole 37 is formed in the valve seat 35. That is, the valve housing 33 (specifically, the valve hole forming wall 34) functions as a first valve hole forming member. The valve seat 35 functions as a second valve hole forming member. The second valve hole 37 opens on the seating face 351. A chamber 46 is defined between the valve seat 35 and the fixed iron core 42. The transmission rod 45 extends through the chamber 46 and the second valve hole 37. A spring seat 55 is located in the chamber 46 and attached to the transmission rod 45. An urging spring 56 is located between the spring seat 55 and the valve seat 35. The transmission rod 45 is urged by the force of the urging spring 56 in a direction moving the movable iron core 44 away from the fixed iron core 42. The chamber 46 communicates with the suction chamber 131 through a passage 57.

[0022] As shown in Fig. 2(b), a shared chamber 38 is defined between the valve hole forming wall 34 and the valve seat 35 (between the first valve hole 36 and the second valve hole 37). The shared chamber 38 is connected to the first valve hole 36 and the second valve hole 37. The shared chamber 38 communicates with the control pressure chamber 121 through a passage 58.

[0023] A first valve body 39 is integrally formed with (fixed to) the transmission rod 45. That is, the first valve body 39 functions as a fixed valve body that is fixed to the transmission rod 45 functioning as a reciprocating body. The first valve body 39 includes a cylindrical portion 391 and a tapered portion 392. The diameter of the tapered portion 392 is reduced in a direction from the second valve hole 37 to the first valve hole 36.

[0024] A second valve body 40 is accommodated in the shared chamber 38. The second valve body 40 functions as a sliding valve body that is slidably fitted around the transmission rod 45. The cylindrical portion 391 of the first valve body 39 is configured to enter and close the first valve hole 36, while the second valve body 40 is configured to contact a seating face 351 of the valve seat 35 and close the second valve hole 37. The second valve body 40 has a valve closing face 403 that contacts the seating face 351 to close the corresponding second valve hole 37.

[0025] A compression spring 47 is located between an opposing face 341 of the valve hole forming wall 34 and the second valve body 40. The compression spring 47 urges the second valve body 40 toward a closing position at which the second valve body 40 closes the second valve hole 37 (a position where the second valve body 40 contacts the seating face 351 of the valve seat 35). A step 451 is formed on the transmission rod 45. The second valve body 40 selectively contacts the step 451. Specifically, the step 451 can contact the valve closing face 403 of the second valve body 40. The second valve body 40 is urged toward the step 451 by the force of the compression spring 47.

[0026] A distance H1 (see Fig. 2(b)) between the step 451 and a boundary 393 between the cylindrical portion 391 of the first valve body 39 and the tapered portion 392 is greater than a distance K1 (see Fig. 2(b)) between an open end 361 of the first valve hole 36 and the seating face 351. The boundary 393 functions as a first initial contact portion, or a portion of the first valve body 39 that initially contacts the circumferential surface of the first valve hole 36 when the first valve body 39 switches the corresponding first valve hole 36 from the open state to the closed state. The open end 361 of the first valve hole 36 functions as a second initial contact portion, which is a portion of the circumferential surface of the first valve hole 36 that initially contacts the boundary 393 when the first valve hole 36 is switched from the open state to the closed state.

[0027] As shown in Fig. 2(a), pressure sensing chambers 48, 49 are defined in the displacement control valve 32 by a bellows 50. A stationary end of the bellows 50 is coupled to an end wall 51 forming the valve housing 33. A movable end of the bellows 50 is coupled to a movable body 52, which functions as a movable portion. An end face 452 of the transmission rod 45 always contacts the movable body 52.

[0028] The pressure sensing chamber 48 communicates with the section 28A of the external refrigerant circuit 28, which is upstream of the constriction 281, through a passage 53A, while the pressure sensing chamber 49 communicates with the section 28B of the external refrigerant circuit 28, which is downstream of the constriction 281, through a passage 53B. That is, the interior of the pressure sensing chamber 48 is exposed to the pressure of the circuit section 28A, which is upstream of the constriction 281, while the interior of the pressure sensing chamber 49 is exposed to the pressure of the circuit section 28B, which is downstream of the constriction 281 and upstream of the heat exchanger 29. The pressure in the pressure sensing chamber 48 and the pressure in the pressure sensing chamber 49 oppose each other with the bellows 50 in between.

[0029] The pressure sensing chambers 48, 49 and the bellows 50 form a pressure sensing member 54 that senses the pressure difference between the pressure of the circuit section 28A, which is upstream of the constriction 281, and the pressure of the circuit section 28B, which is downstream of the constriction 281 and upstream of the heat exchanger 29. When refrigerant is flowing through the circuit sections 28A, 28B, the pressure of the circuit section 28A, which is upstream of the constriction 281, is higher than the pressure of the circuit section 28B, which is downstream of the constriction 281 and upstream of the heat exchanger 29. When the flow rate of refrigerant in the circuit sections 28A, 28B (discharge pressure zone) is increased, the pressure difference between the sections upstream and downstream of the constriction 281 is increased. When the flow rate of refrigerant in the circuit sections 28A, 28B (discharge pressure zone) is decreased, the pressure difference between the section upstream and downstream of the constriction 281 is reduced. When the pressure difference between the sections upstream and downstream of the constriction 281 is increased, the pressure difference between the pressure sensing chambers 48, 49 is increased. When the pressure difference between the sections upstream and downstream of the constriction 281 is reduced, the pressure difference between the pressure sensing chambers 48, 49 is reduced. The pressure difference between the pressure sensing chambers 48, 49 acts as force that urges the movable body 52 and the transmission rod 45 in a direction from the first valve hole 36 to the second valve hole 37.

[0030] The control computer C shown in Fig. 1 executes the current supply control (duty ratio control) for the solenoid 41 of the displacement control valve 32. When an air-conditioner switch 59 is ON, the control computer C supplies current to the solenoid 41. When the air-conditioner switch 59 is OFF, the control computer C stops supplying the current. The control computer C is connected to a compartment temperature setting device 60 and a compartment temperature detector 61. When the air-conditioner switch 59 is ON, the control computer C controls current supplied to the solenoid 41 based on the difference between a target compartment temperature set by the compartment temperature setting device 60 and the temperature detected by the compartment temperature detector 61.

[0031] Figs. 1, 2(a), and 2(b) show a state in which the air-conditioner switch 59 is ON, and the current control (duty ratio control) is being executed based on the difference between a target temperature set by manipulating the compartment temperature setting device 60 and the temperature detected by the compartment temperature detector 61. In Figs. 1, 2(a), and 2(b), the duty ratio is set to 100% in the control of current to the solenoid 41. In this state, the movable iron core 44 is closest to the fixed iron core 42. The step 451 of the transmission rod 45 contacts the second valve body 40, and the second valve body 40 is at an opening position separated from the seating face 351 of the valve seat 35. Since the second valve hole 37 is open, refrigerant in the shared chamber 38 flows to the chamber 46 through the second valve hole 37. That is, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the pressure sensing chamber 49 does not flow into the shared chamber 38 through the first valve hole 36. Also, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Figs. 1, 2(a), and 2(b), the displacement control valve 32 does not allow refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121, while allowing refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 is maximized. Accordingly, the variable displacement compressor 10 operates at the maximum displacement.

[0032] Figs. 2(c), 3(a), and 3(b) show a state in which the air-conditioner switch 59 is ON, and the current control (duty ratio control) is being executed based on the difference between a target temperature set by manipulating the compartment temperature setting device 60 and the temperature detected by the compartment temperature detector 61.

[0033] In the state of Fig. 2(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. In this state, the step 451 of the transmission rod 45 contacts the second valve body 40, and the second valve body 40 is at an opening position separated from the seating face 351 of the valve seat 35. Since the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Fig. 2(c), the displacement control valve 32 does not allow refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121, while allowing refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0034] The opening degree of the second valve hole 37 in the state of Fig. 2(c) is less than that in the state of Fig. 2

(b). In the state of Fig. 2(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0035] In the state of Fig. 3(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 2(c). In the illustrated state, the step 451 of the transmission rod 45 contacts the second valve body 40, and the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36). The second valve body 40 is in a position where it contacts the seating face 351 of the valve seat 35 (a position where the second valve body 40 closes the second valve hole 37). That is, the second valve hole 37 is closed by the second valve body 40.

[0036] In the state of Fig. 3(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 3(a). In the illustrated state, the step 451 of the transmission rod 45 is separated from the second valve body 40, and the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36). The second valve body 40 is in a position where it contacts the seating face 351 of the valve seat 35 (a position where the second valve body 40 closes the second valve hole 37). That is, the second valve hole 37 is closed by the second valve body 40.

[0037] In either of the states shown in Figs. 3(a) and 3(b), the first valve body 39 is in a position where it closes the first valve hole 36, and the second valve body 40 is in a position where it closes the second valve hole 37. As the electromagnetic force of the solenoid 41 is reduced from the state of Fig. 3(a) (a state in which the end face 452 of the transmission rod 45 is in a position W1), the end face 452 of the transmission rod 45 is moved from the position W1 toward the first valve hole 36, and the step 451 is separated from the second valve body 40. As the electromagnetic force of the solenoid 41 is increased from the state of Fig. 3(b) (a state in which the end face 452 of the transmission rod 45 is in a position W2), the end face 452 of the transmission rod 45 is moved from the position W2 toward the position W1, and the step 451 approaches the second valve body 40. If the end face 452 of the transmission rod 45 is in a displacement range [W1, W2] from the position W1 to the position W2, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36), and the second valve body 40 is in the position where it contacts the seating face 351 of the valve seat 35 (a position where the second valve body 40 closes the second valve hole 37).

[0038] The displacement range [W1, W2] is a predetermined range of a double closing state of the transmission rod 45, in which the first valve body 39 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37. When the transmission rod 45, which is a reciprocating body, is in the predetermined displacement range [W1, W2], the double closing state occurs, in which the first valve body 39 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37. This state is obtained because the distance H1 between the step 451 and the boundary 393 is greater than the distance K1 between the open end 361 and the seating face 351. That is, to ensure that a the predetermined displacement range [W1, W2] be created, the distance H1 between the displacement transmission portion (the step 451) and the first initial contact portion (the boundary 393 of the first valve body 39) is different from the distance K1 between the second initial contact portion (the open end 361 of the first valve hole 36) and the seating face 351.

[0039] In Figs. 3(a) and 3(b), since the second valve hole 37 is closed, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone). On the other hand, since the first valve hole 36 is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Figs. 3(a) and 3(b), the displacement control valve 32 does not allow refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32 also does not allow refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0040] If the duty ratio is further reduced from the state of Fig. 3(b), the state shown in Fig. 3(c) is obtained (including a case where the duty ratio is zero). In this state, this control is executed when the variable displacement compressor 10 is operated at a small displacement or when the speed of the vehicle engine E is abruptly increased while the air-conditioner switch 59 is ON.

[0041] The step 451 of the transmission rod 45 is separated from the second valve body 40, and the second valve body 40 is in the position where it contacts the seating face 351 of the valve seat 35 (the position where it closes the second valve hole 37). Since the second valve hole 37 is closed, refrigerant in the shared chamber 38 does not flow out to the chamber 46 through the second valve hole 37. That is, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the cylindrical portion 391 of the first valve body 39 is out of the first valve hole 36 so that the first valve hole 36 is open. Since the first valve hole 36 is open, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, the displacement control valve 32 allows refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121, while preventing refrigerant in the control pressure chamber 121 from flowing out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0042] In the state of Fig. 3(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 39 opens the first valve hole 36, and the second valve body 40 closes the second valve hole 37. In the state of Figs. 2(b) and 2(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 39 closes the first valve hole 36, and the second valve body 40 opens the second valve hole 37. That is, when the transmission rod 45 is out of the predetermined displacement range [W1, W2], one of the state in which the first valve body 39 closes the first valve hole 36, and the state in which the second valve body 40 closes the second valve hole 37 occurs. In other words, when the transmission rod 45 is out of the displacement range ([W1, W2]), a single closing state occurs, in which only one of the first valve body 39 and the second valve body 40 closes the corresponding one of the valve holes 36, 37.

[0043] In the state of Fig. 2(c) or the state of Figs. 3(a) and 3(b), if the rotation speed of the variable displacement compressor 10 is increased, the flow rate of refrigerant through the circuit sections 28A, 28B is increased. This increases the pressure difference between the refrigerant pressure in the circuit section 28A and the refrigerant pressure in the circuit section 28B. The pressure sensing member 54 moves the transmission rod 45 in a direction from the first valve hole 36 to the second valve hole 37 based on the increase in the pressure difference. When the cylindrical portion 391 of the first valve body 39 is out of the first valve hole 36, the first valve hole 36 is open. When the first valve hole 36 is open, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. This increases the pressure in the control pressure chamber 121, thereby reducing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is reduced.

[0044] In the state of Figs. 3(a) to 3(c), if the rotation speed of the variable displacement compressor 10 is reduced, the flow rate of refrigerant through the circuit sections 28A, 28B is reduced. This reduces the pressure difference between the refrigerant pressure in the circuit section 28A and the refrigerant pressure in the circuit section 28B. This moves the transmission rod 45 in a direction from the second valve hole 37 to the first valve hole 36. When the step 451 of the transmission rod 45 contacts the second valve body 40, and the second valve body 40 is separated from the seating face 351 of the valve seat 35, the second valve hole 37 is open. When the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 58, the shared chamber 38, the second valve hole 37, and the passage 57. This reduces the pressure in the control pressure chamber 121, thereby increasing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is increased.

[0045] The opening degree of the first valve hole 36 is determined by the balance of the electromagnetic force produced by the solenoid 41, the force of the urging spring 56, and the force of the pressure sensing member 54. The opening degree of the second valve hole 37 is determined by the balance of the electromagnetic force produced by the solenoid 41, the force of the urging spring 56, the force of the compression spring 47, and the force of the pressure sensing member 54. Together with the passage 53B, the pressure sensing chamber 49, the shared chamber 38, and the passage 58, the first valve hole 36 forms a supply passage for supplying refrigerant of the circuit section 28B (discharge pressure zone) to the control pressure chamber 121. Together with the passage 58, the shared chamber 38, the chamber 46, and the passage 57, the second valve hole 37 forms a discharge passage for discharging refrigerant of the control pressure chamber 121 to the suction chamber 131 (suction pressure zone).

[0046] The displacement control valve 32 is a control valve of a valve opening degree changing type, which changes the electromagnetic force (duty ratio), thereby continuously varying the flow passage areas of the first valve hole 36 and the second valve hole 37. The air-conditioner switch 59, the compartment temperature setting device 60, the compartment temperature detector 61, and the control computer C form an electromagnetic force changing unit for changing the electromagnetic force in the displacement control valve 32.

[0047] In this embodiment, carbon dioxide is used as refrigerant.

[0048] The first embodiment provides the following advantages.

(1-1) When the transmission rod 45 is moved from the outside of the predetermined displacement range [W1, W2] into the displacement range [W1, W2], the state is shifted from a state in which one of the first and second valve holes 36, 37 is closed (single closing state) to a state in which both of the first and second valve holes 36, 37 are closed (double closing state). The displacement range [W1, W2] is the difference between the distance H1 between the step 451 and the boundary 393 and the distance K1 between the open end 361 and the seating face 351, and is expressed by (H1 - K1) > 0. Since the displacement range [W1, W2] has a width, the displacement range [W1, W2] is reliably secured even if there are dimensional errors and assembly errors of the components of the displacement control valve 32. That is, when the state is being shifted from a state in which the first valve hole 36 is open and the second valve hole 37 is closed and a state in which the second valve hole 37 is open and the first valve hole 36 is closed, both of the first and second valve holes 36, 37 are closed. In other words, the first valve hole 36 and the second valve hole 37 are not open at the same time.

(1-2) When the second valve body 40 is in the position where it closes the second valve hole 37 (a specific position where it contacts the seating face 351 of the valve seat 35), the second valve body 40 is moveable relative to the transmission rod 45 in a direction opposite to the direction from the first valve hole 36 to the second valve hole 37. If the transmission rod 45 is moved in a direction from the first valve hole 36 to the second valve hole 37 when the second valve body 40 is at the closing position for closing the second valve hole 37, the distance between the boundary 393 of the first valve body 39 and the seating face 351 is changed (shortened). That is, the distance between the first valve body 39 and the second valve body 40 is changed according to the displacement of the transmission rod 45. This configuration, in which the distance is changeable, permits the second valve body 40 to be located at the closing position for closing the second valve hole 37 (specific position) when the transmission rod 45 is in the predetermined displacement range [W1, W2]. This configuration, in which the distance is changeable, is suitable for realizing the double closing state, in which the first valve body 39 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37 when the transmission rod 45 is in the predetermined displacement range [W1, W2].

When the transmission rod 45 is outside of the displacement range [W1, W2], and the step 451 of the transmission rod 45 is not contacting the second valve body 40, the second valve body 40 closes the second valve hole 37 by means of the force of the compression spring 47. The step 451, which functions as a displacement transmission portion for separating the second valve body 40 from the closing position for closing the second valve hole 37, and a distance changing mechanism having the compression spring 47, which functions as an urging member for causing the second valve body 40 to contact the valve seat 35, are suitable as means for changing the distance between the first valve body 39 and the second valve body 40 according to the position of the transmission rod 45. When the second valve body 40 closes the second valve hole 37 at a specific position, the distance changing mechanism permits the transmission rod 45 to be displaced relative to the second valve body 40 at the specific position.

(1-3) When the transmission rod 45 is in the predetermined displacement range [W1, W2], the first valve body 39 is in the first valve hole 36 to close the first valve hole 36. The configuration in which the first valve body 39 fixed to the transmission rod 45 is caused to enter and close the first valve hole 36 is a simplified configuration for closing the first valve hole 36 when the transmission rod 45 is in the predetermined displacement range [W1, W2].

(1-4) If the flow passage area of the first valve hole 36, which is a part of the supply passage, is finely changed, the compressor displacement can be finely controlled. The first valve body 39 has the tapered portion 392, which is selectively inserted into the first valve hole 36. The tapered portion 392 is a favorable structure for finely changing the flow passage area of the first valve hole 36 according to the position of the first valve body 39 when the first valve body 39 is in the first valve hole 36. The tapered portion 392 is advantageous for permitting the cylindrical portion 391 outside of the first valve hole 36 to smoothly enter the first valve hole 36.

(1-5) The greater the pressure difference between the pressure in the discharge pressure zone and the pressure in the control pressure chamber 121, and the greater the pressure difference between the pressure in the control pressure chamber 121 and the pressure in the suction pressure zone, the more likely refrigerant flows out from the discharge pressure zone to the suction pressure zone through the supply passage, the control pressure chamber 121, and the discharge passage. When refrigerant flows from the discharge pressure zone to the control pressure chamber 121 through the supply passage, and flows to the suction pressure zone from the control pressure chamber 121 through the discharge passage, the flow of refrigerant is wasteful and reduces the efficiency of the compressor. The greater the flow rate of refrigerant that flows from the discharge pressure zone to the suction pressure zone through the control pressure chamber 121, the more reduced the compressor efficiency becomes.

The refrigerant pressure in a case where carbon dioxide is used as the refrigerant is significantly higher than the refrigerant pressure in a case where chlorofluorocarbon gas is used as refrigerant. That is, the pressure difference between the pressure in the discharge pressure zone and the pressure in the control pressure chamber 121, and the pressure difference between the pressure in the control pressure chamber 121 and the pressure in the suction pressure zone (the suction chamber 131) are significantly greater in a case where carbon dioxide is used as the refrigerant than in a case where chlorofluorocarbon gas is used as the refrigerant. Therefore, in a case where carbon dioxide is used as the refrigerant, wasteful flow of refrigerant from the discharge pressure zone to the suction pressure zone through the control pressure chamber 121 affects the compressor efficiency by a great degree.

In this embodiment, the first valve hole 36 and the second valve hole 37 are not open at the same time. This prevents carbon dioxide, which is used as refrigerant, from wastefully flowing from the discharge pressure zone to the suction pressure zone through the control pressure chamber 121. That is, the displacement control valve 32, which does not open the first valve hole 36 and the second valve hole 37 at the same time, is suitable as a displacement control valve used in the variable displacement compressor 10, which uses carbon dioxide as the refrigerant.

(1-6) Since the first valve body 39 is integrated with the transmission rod 45, the number of the components is reduced, and the valve mechanism is simplified.

[0049] A second embodiment will now be described with reference to Figs. 4(a) and 4(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c).

[0050] A first chamber 63 and a second chamber 64 are defined by a separation member 62 between the valve hole forming wall 34 and the valve seat 35. The first chamber 63 is connected to the first valve hole 36, and the second chamber 64 is connected to the second valve hole 37. The first chamber 63 communicates with the control pressure chamber 121 through a passage 65, and the second chamber 64 communicates with the control pressure chamber 121 through a passage 66. The compression spring 47 is located between the separation member 62 and the second valve body 40 and urges the second valve body 40 in a direction from the first valve hole 36 to the second valve hole 37. The distance H1 between the step 451 and the boundary 393 is greater than the distance K1 between the open end 361 and the seating face 351 of the valve seat 35.

[0051] When the cylindrical portion 391 of the first valve body 39 is out of the first valve hole 36, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36, the first chamber 63, and the passage 65. When the second valve body 40 is separated from the seating face 351, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 66, the second chamber 64, the second valve hole 37, the chamber 46, and the passage 57. When the transmission rod 45 is in the predetermined displacement range [W1, W2], the first valve body 39 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37.

[0052] The second embodiment has the same advantages as the advantages (1-1) to (1-6) of the first embodiment.

[0053] A third embodiment will now be described with reference to Figs. 5(a) to 6(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c).

[0054] As shown in Figs. 5(a) and 5(b), a first valve body 67 is accommodated in the shared chamber 38 between a valve seat 69 and a valve hole forming plate 70. The first valve body 67 is slidably fitted around a sliding portion 453 formed on the transmission rod 45. The first valve body 67 has a valve closing face 673 that contacts the seating face 691 of the valve seat 69 to close the corresponding first valve hole 36.

[0055] A second valve body 68 is integrally formed with (fixed to) the transmission rod 45. The second valve body 68 includes a cylindrical portion 681 and a tapered portion 682. The diameter of the tapered portion 682 is reduced in a direction from the first valve hole 36 to the second valve hole 37. The cylindrical portion 681 of the second valve body 68 is configured to enter and close the second valve hole 37, while the first valve body 67 is configured to contact a seating face 691 of the valve seat 69 and close the first valve hole 36.

[0056] A compression spring 71 is located between the valve hole forming plate 70 and the first valve body 67. The compression spring 71 urges the first valve body 67 toward a closing position at which the first valve body 67 closes the first valve hole 36 (a position where the first valve body 67 contacts the seating face 691 of the valve seat 69).

[0057] An auxiliary rod 72 is attached to the movable body 52 of the pressure sensing member 54 at a coupling face 722. An end face 721 of the auxiliary rod 72 always contacts an end face 454 of the transmission rod 45. The diameter of the end face 721 of the auxiliary rod 72, which forms a reciprocating body with the transmission rod 45, is greater than the diameter of the end face 454 of the sliding portion 453. The end face 721 of the auxiliary rod 72 selectively contacts the first valve body 67. The valve body 67 is urged toward the end face 721 by the force of the compression spring 71.

[0058] A distance H2 (see Fig. 5(b)) between the end face 721 and a boundary 683 between the cylindrical portion 681 of the second valve body 68 and the tapered portion 682 is greater than a distance K2 (see Fig. 5(b)) between an open end 371 of the second valve hole 37 and the seating face 691.

[0059] In Figs. 5(a), and 5(b), the duty ratio is set to 100% in the control of current to the solenoid 41. The end face 721 of the auxiliary rod 72 is farthest from the first valve hole 36, and the second valve body 68 is located at an opening position away from the second valve hole 37. Since the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the first valve body 67 contacts the seating face 691 of the valve seat 69 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Figs. 5(a) and 5(b), the displacement control valve 32 does not allow refrigerant in the circuit section 28A (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32 also allows refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 is maximized. Accordingly, the variable displacement compressor

10 operates at the maximum displacement.

[0060] In the state of Fig. 5(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. In this state, the tapered portion 682 of the second valve body 68 is in the second valve hole 37, while the boundary 683 is not in the second valve hole 37. That is, the second valve body 68 is at the opening position, where it opens the second valve hole 37. Since the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the first valve body 67 contacts the seating face 691 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Fig. 5(c), the displacement control valve 32 does not allow refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121, while allowing refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0061] The opening degree of the second valve hole 37 in the state of Fig. 5(c) is less than that in the state of Fig. 5 (b). In the state of Fig. 5(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0062] In the state of Fig. 6(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 5(c). In the illustrated state, the end face 721 of the auxiliary rod 72 is separated from the first valve body 67, and the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37). The first valve body 67 is in a position where it contacts the seating face 691 of the valve seat 69 (a position where the first valve body 67 closes the first valve hole 36). That is, the first valve hole 36 is closed by the first valve body 67.

[0063] In the state of Fig. 6(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 6(a). In the illustrated state, the end face 721 of the auxiliary rod 72 contacts the first valve body 67, and the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the first valve hole 36). The second valve hole 37 is closed by the second valve body 68. The first valve body 67 is in a position where it contacts the seating face 691 of the valve seat 69 (a position where the first valve body 67 closes the first valve hole 36). That is, the first valve hole 36 is closed by the first valve body 67.

[0064] As the electromagnetic force of the solenoid 41 is reduced from the state of Fig. 6(a) (a state in which the coupling face 722 of the auxiliary rod 72 is located in a position W1 relative to the movable body 52), the end face 721 of the auxiliary rod 72 approaches the first valve body 67. As the electromagnetic force of the solenoid 41 is increased from the state of Fig. 6(b) (a state in which the coupling face 722 is in the position W2), the end face 721 of the auxiliary rod 72 is moved from the position W2 toward the position W1. If the coupling face 722 of the auxiliary rod 72 is in a displacement range [W1, W2] from the position W1 to the position W2, the first valve body 67 is in a position where it contacts the seating face 691 of the valve seat 69 (closing position for closing the first valve hole 36), and the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37).

[0065] The displacement range [W1, W2] is a predetermined range of a double closing state of the transmission rod 45, in which the first valve body 67 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. When the transmission rod 45, which is a reciprocating body, is in the predetermined displacement range [W1, W2], the double closing state occurs, in which the first valve body 67 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. This state is obtained because the distance H2 between the end face 721 and the boundary 683 is greater than the distance K2 between the seating face 691 and the open end 371.

[0066] If the duty ratio is further reduced from the state of Fig. 6(b), the state shown in Fig. 6(c) is obtained (including a case where the duty ratio is zero). The end face 721 of the auxiliary rod 72 contacts the first valve body 67, and the first valve body 67 is separated from the seating face 691. That is, the first valve hole 36 is open. Since the first valve hole 36 is open, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. On the other hand, the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 so that the second valve hole 37 is closed. Since the second valve hole 37 is closed, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. That is, the displacement control valve 32 allows refrigerant in the circuit section 28B (discharge pressure zone) to flow into the control pressure chamber 121, while preventing refrigerant in the control pressure chamber 121 from flowing out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0067] In the state of Fig. 6(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 67 opens the first valve hole 36, and the second valve body 68 closes the second valve hole 37. In the state of Figs. 5(b) and 5(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 67 closes the first valve hole 36, and the second valve body 68 opens the second valve hole 37. That is, when the transmission rod 45 is out of the predetermined displacement range [W1, W2], one of the state in which the first valve body 67 closes the first valve hole 36, and the state in which the second valve body 68 closes the second valve hole 37 occurs.

[0068] The third embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment. Further, the third embodiment provides the following advantages.

(3-1) The distance between the first valve body 67 and the second valve body 68 is changed according to the displacement of the transmission rod 45. This configuration, in which the distance is changeable, permits the first valve body 67 to be located at the closing position for closing the first valve hole 36 (specific position) when the transmission rod 45 is in the predetermined displacement range [W1, W2]. This configuration, in which the distance is changeable, is suitable for realizing the double closing state, in which the first valve body 67 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37 when the transmission rod 45 is in the predetermined displacement range [W1, W2].

When the transmission rod 45 is outside of the displacement range [W1, W2], and the end face 721 of the auxiliary rod 72 is not contacting the first valve body 67, the first valve body 67 closes the first valve hole 36 by means of the force of the compression spring 71. The end face 721 for separating the first valve body 67 from the closing position for closing the first valve hole 36, and a distance changing mechanism having the compression spring 71 for causing the first valve body 67 to contact the valve seat 69, are suitable as means for changing the distance between the first valve body 67 and the second valve body 68 according to the position of the transmission rod 45.

(3-2) When the transmission rod 45 is in the predetermined displacement range [W1, W2], the second valve body 68 is in the second valve hole 37 to close the second valve hole 37. The configuration in which the second valve body 68 fixed to the transmission rod 45 is caused to enter and close the second valve hole 37 is a simplified configuration for closing the second valve hole 37 when the transmission rod 45 is in the predetermined displacement range [W1, W2].

(3-3) If the flow passage area of the second valve hole 37, which is a part of the discharge passage, is finely changed, the compressor displacement can be finely controlled. The second valve body 68 has the tapered portion 682, which is selectively inserted into the second valve hole 37. The tapered portion 682 is a favorable structure for finely changing the flow passage area of the second valve hole 37 according to the position of the second valve body 68 when the second valve body 68 is in the second valve chamber 37. The tapered portion 682 is advantageous for permitting the cylindrical portion 681 outside of the second valve hole 37 to smoothly enter the second valve hole 37.

(3-4) Since the second valve body 68 is integrated with the transmission rod 45, the number of the components is reduced, and the valve mechanism is simplified.

[0069] A fourth embodiment will now be described with reference to Fig. 7. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the second embodiment shown in Figs. 4(a) and 4(b) and the third embodiment shown in Figs. 5(a) to 6(c).

[0070] A first chamber 74 and a second chamber 75 are defined by a separation member 73 between the valve seat 69 and the valve hole forming plate 70. The first chamber 74 is connected to the first valve hole 36, and the second chamber 75 is connected to the second valve hole 37. The first chamber 74 communicates with the control pressure chamber 121 through a passage 65, and the second chamber 75 communicates with the control pressure chamber 121 through a passage 66. The compression spring 76 is located between the separation member 73 and the first valve body 67 and urges the first valve body 67 in a direction from the second valve hole 37 to the first valve hole 36. The distance H2 between the end face 721 and the boundary 683 is greater than the distance K2 between the seating face 691 and the open end 371.

[0071] When the first valve body 67 does not contact the seating face 691, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36, the first chamber 74, and the passage 65. When the cylindrical portion 681 of the second valve body 68 is out of the second valve hole 37, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 66, the second chamber 75, the second valve hole 37, the chamber 46, and the passage 57. When the transmission rod 45 is in the predetermined displacement range [W1, W2], the first valve body 67 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37.

[0072] The fourth embodiment thus provides the same advantages as the third embodiment.

[0073] A fifth embodiment will now be described with reference to Figs. 8(a) and 8(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c) and the third embodiment shown in Figs. 5(a) to 6(c).

[0074] In the fifth embodiment, the first valve body 39 of the first embodiment and the second valve body 68 of the third embodiment are used together. That is, the first valve body 39 and the second valve body 68 are both integrally formed with (fixed to) the transmission rod 45. That is, both of the first valve body 39 and the second valve body 68 are fixed valve bodies that are fixed to the transmission rod 45. A distance H3 between the boundary 393 of the first valve body 39 and the boundary 683 of the second valve body 68 is greater than a distance K3 between the open end 361 of the first valve hole 36 and the open end 371 of the second valve hole 37.

[0075] When the transmission rod 45 is in the predetermined displacement range [W1, W2], a double closing state occurs, in which the first valve body 39 is in the first valve hole 36 and closes the first valve hole 36, and the second valve body 68 is in the second valve hole 37 and closes the second valve hole 37. In other words, in the double closing state, the first valve body 39 enters the first valve hole 36 to close the first valve hole 36. When the transmission rod 45 is in the predetermined displacement range [W1, W2], the valve bodies 39, 68 fixed to the transmission rod 45 are in positions closing the valve holes 36, 37. When the transmission rod 45 is moved from the inside of the predetermined displacement range [W1, W2] to the outside of the displacement range [W1, W2], one of the valve bodies 39, 68 opens the corresponding valve hole (36 or 37), and the other valve body closes the corresponding valve hole (37 or 36).

[0076] The fifth embodiment has the same advantages as the advantages (1-1), (1-3) to (1-6) of the first embodiment, and the advantages (3-2) to (3-4) of the third embodiment.

[0077] A sixth embodiment will now be described with reference to Figs. 9(a), 9(b), 9(c), 10(b), and 10(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c).

[0078] As shown in Fig. 9(a), a displacement control valve 32A includes a solenoid 41A. A fixed iron core 42A of the solenoid 41 attracts a movable iron core 44A based on excitation by current supplied to a coil 43A. An urging spring 80 is located between the fixed iron core 42A and the movable iron core 44A. The urging spring 80 urges the movable iron core 44A in a direction away from the fixed iron core 42A. A transmission rod 45A is fixed to the movable iron core 44A.

[0079] The pressure sensing chamber 48 communicates with a section 28B of the external refrigerant circuit 28, which is downstream of the constriction 281, through a passage 53B, while the pressure sensing chamber 49 communicates with a section 28A of the external refrigerant circuit 28, which is upstream of the constriction 281, through a passage 53A. That is, the pressure sensing chamber 48 is exposed to the pressure in the circuit section 28B, and the pressure sensing chamber 49 is exposed the pressure of the circuit section 28A. The pressure in the pressure sensing chamber 48 and the pressure in the pressure sensing chamber 49 oppose each other with the bellows 50 in between.

[0080] The pressure sensing chambers 49, 48 and the bellows 50 form a pressure sensing member 54A that senses the pressure difference between the pressure of the circuit section 28A, which is upstream of the constriction 281, and the pressure of the circuit section 28B, which is downstream of the constriction 281 and upstream of the heat exchanger 29.

[0081] A valve housing 33A, which forms the displacement control valve 32A, has a valve hole forming portion 77. A first valve hole 36A, a shared passage 78, and a second valve hole 37A are formed in the valve hole forming portion 77. The first valve hole 36A and the second valve hole 37A communicate with each other through the shared passage 78. The shared passage 78 communicates with the control pressure chamber 121 through the passage 58. An accommodation chamber 79 is defined between the valve hole forming portion 77 and the movable iron core 44A. The accommodation chamber 79 communicates with the suction chamber 131 through a passage 57. The transmission rod 45A extends through the accommodation chamber 79, the second valve hole 37A, the shared passage 78, and the first valve hole 36A, and projects into the pressure sensing chamber 49. The transmission rod 45A is attached to the movable body 52 at an end face 455.

[0082] When the flow rate of refrigerant in the circuit sections 28A, 28B (discharge pressure zone) is increased, the pressure difference between the sections upstream and downstream of the constriction 281 is increased. When the flow rate of refrigerant in the circuit sections 28A, 28B (discharge pressure zone) is decreased, the pressure difference between the section upstream and downstream of the constriction 281 is reduced. When the pressure difference between the sections upstream and downstream of the constriction 281 is increased, the pressure difference between the pressure sensing chambers 48, 49 is increased. When the pressure difference between the sections upstream and downstream of the constriction 281 is reduced, the pressure difference between the pressure sensing chambers 48, 49 is reduced. The pressure difference between the pressure sensing chambers 48, 49 acts as force that urges the movable body 52 in a direction from the second valve hole 37A to the first valve hole 36A.

[0083] As shown in Fig. 9(b), the first valve body 39A includes a cylindrical portion 394 and a tapered portion 395. The diameter of the tapered portion 395 is increased in a direction from the second valve hole 37A to the first valve hole 36A.

[0084] A second valve body 40A is accommodated in the accommodation chamber 79. The second valve body 40A is slidably fitted around the transmission rod 45A. The cylindrical portion 394 of the first valve body 39A is configured to enter and close the first valve hole 36A, while the second valve body 40A is configured to contact a seating face 771 of the valve hole forming portion 77 and close the second valve hole 37A.

[0085] A compression spring 82 is located between a spring seat 81 and the second valve body 40A. The compression spring 82 urges the second valve body 40A toward a closing position at which the second valve body 40A closes the second valve hole 37A (a position where the second valve body 40A contacts the seating face 771). A step 456 is formed on the transmission rod 45A. The second valve body 40A selectively contacts the step 456. The second valve body 40A is urged toward the step 456 by the force of the compression spring 82.

[0086] A distance H4 (see Fig. 9(b)) between the step 456 and a boundary 396 between the cylindrical portion 394 of the first valve body 39A and the boundary 396 is less than a distance K4 (see Fig. 9(b)) between an open end 362 of the first valve hole 36A and the seating face 771.

[0087] In Figs. 9(a) and 9(b), the duty ratio is set to 100% in the control of current to the solenoid 41A. In this state, the movable iron core 44A is closest to the fixed iron core 42A. The step 456 of the transmission rod 45A contacts the second valve body 40A, and the second valve body 40A is at an opening position separated from the seating face 771. Since the second valve hole 37A is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared passage 78, the second valve hole 37A, the accommodation chamber 79, and the passage 57. On the other hand, the cylindrical portion 394 of the first valve body 39A is in the first valve hole 36A so that the first valve hole 36A is closed. Since the first valve hole 36A is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36A, the shared passage 78, and the passage 58. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 is maximized. Accordingly, the variable displacement compressor 10 (see Fig. 1) operates at the maximum displacement.

[0088] In the state of Fig. 9(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. In this state, the step 456 of the transmission rod 45A contacts the second valve body 40A, and the second valve body 40A is at an opening position separated from the seating face 771. Since the second valve hole 37A is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared passage 78, the second valve hole 37A, the accommodation chamber 79, and the passage 57. On the other hand, the cylindrical portion 394 of the first valve body 39A is in the first valve hole 36A so that the first valve hole 36A is closed. Since the first valve hole 36A is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36A, the shared passage 78, and the passage 58.

[0089] The opening degree of the second valve hole 37A in the state of Fig. 9(c) is less than that in the state of Fig. 9(b). In the state of Fig. 9(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0090] In the state of Fig. 10(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 9(c). In the illustrated state, the step 456 of the transmission rod 45A contacts the second valve body 40A, and the cylindrical portion 394 of the first valve body 39A is in the first valve hole 36A (the boundary 396 is in the first valve hole 36A). The second valve body 40A is in a position where it contacts the seating face 771 (a position where the second valve body 40A closes the second valve hole 37A). That is, the second valve hole 37A is closed by the second valve body 40A.

[0091] In the state of Fig. 10(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 10(a). In the illustrated state, the step 456 of the transmission rod 45A is separated from the second valve body 40A, and the cylindrical portion 394 of the first valve body 39A is in the first valve hole 36A (the boundary 396 is in the first valve hole 36A). The second valve body 40A is in a position where it contacts the seating face 771 (a position where the second valve body 40A closes the second valve hole 37A). That is, the second valve hole 37A is closed by the second valve body 40A.

[0092] In either of the states shown in Figs. 10(a) and 10(b), the cylindrical portion 394 of the first valve body 39A is in the first valve hole 36A, and the second valve body 40A is in a position where it closes the second valve hole 37A. As the electromagnetic force of the solenoid 41A is reduced from the state of Fig. 10(a) (a state in which the end face 455 of the transmission rod 45A is in a position W3), the end face 455 of the transmission rod 45 is moved away from the first valve hole 36A, so that the step 456 is separated from the second valve body 40A. As the electromagnetic force of the solenoid 41A is increased from the state of Fig. 10(b) (a state in which the end face 455 of the transmission rod 45A is in a position W4), the end face 455 of the transmission rod 45A is moved from the position W4 toward the position W3, and the step 456 approaches the second valve body 40A.

[0093] The displacement range [W3, W4] is a predetermined range of a double closing state of the transmission rod 45A, in which the first valve body 39A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A. When the transmission rod 45A, which is a reciprocating body, is in the predetermined displacement range [W3, W4], the double closing state occurs, in which the first valve body 39A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A. This state is obtained because the distance H4 between the step 456 and the boundary 396 is less than the distance K4 between the open end 362 of the first valve hole 36A and the seating face 771.

[0094] In Figs. 10(a) and 10(b), since the second valve hole 37A is closed, refrigerant in the control pressure chamber

121 does not flow out to the suction chamber 131 (suction pressure zone). On the other hand, since the first valve hole 36A is closed, refrigerant in the pressure sensing chamber 49 does not flow into the control pressure chamber 121 through the first valve hole 36A, the shared passage 78, and the passage 58. That is, in the state shown in Figs. 10(a) and 10(b), the displacement control valve 32A does not allow refrigerant in the circuit section 28A (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32A also does not allow refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0095] If the duty ratio is further reduced from the state of Fig. 10(b), the state shown in Fig. 10(c) is obtained (including a case where the duty ratio is zero).

[0096] The step 456 of the transmission rod 45A is separated from the second valve body 40A, and the second valve body 40A is in the position where it contacts the seating face 771 (the closing position for closing the second valve hole 37A). Since the second valve hole 37A is closed, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared passage 78, the second valve hole 37A, the accommodation chamber 79, and the passage 57. On the other hand, the cylindrical portion 394 of the first valve body 39A is out of the first valve hole 36A so that the first valve hole 36A is open. Since the first valve hole 36A is open, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36A, the shared passage 78, and the passage 58. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0097] In the state of Fig. 9(c) or the state of Figs. 10(a) and 10(b), if the rotation speed of the variable displacement compressor 10 is increased, the flow rate of refrigerant through the circuit sections 28A, 28B is increased. This increases the pressure difference between the refrigerant pressure in the circuit section 28A and the refrigerant pressure in the circuit section 28B. The pressure sensing member 54A moves the transmission rod 45A in a direction from the second valve hole 37A to the first valve hole 36A based on the increase in the pressure difference. When the cylindrical portion 394 of the first valve body 39A is out of the first valve hole 36A, the first valve hole 36A is open. When the first valve hole 36A is open, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36A, the shared passage 78, and the passage 58. This increases the pressure in the control pressure chamber 121, thereby reducing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is reduced.

[0098] In the state of Figs. 10(a), 10(b), and 10(c), if the rotation speed of the variable displacement compressor 10 is reduced, the flow rate of refrigerant through the circuit sections 28A, 28B is reduced. This reduces the pressure difference between the refrigerant pressure in the circuit section 28A and the refrigerant pressure in the circuit section 28B. This moves the transmission rod 45A in a direction from the first valve hole 36A to the second valve hole 37A. When the step 456 of the transmission rod 45A contacts the second valve body 40A, and the second valve body 40A is separated from the seating face 771, the second valve hole 37A is open. When the second valve hole 37A is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 58, the shared passage 78, the second valve hole 37A, and the passage 57. This reduces the pressure in the control pressure chamber 121, thereby increasing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is increased.

[0099] The opening degree of the first valve hole 36A is determined by the balance of the electromagnetic force produced by the solenoid 41A, the force of the urging spring 80, and the force of the pressure sensing member 54A. The opening degree of the second valve hole 37A is determined by the balance of the electromagnetic force produced by the solenoid 41A, the force of the urging spring 80, the force of the compression spring 82, and the force of the pressure sensing member 54A. Together with the passage 53A, the pressure sensing chamber 49, the shared passage 78, and the passage 58, the first valve hole 36A forms a supply passage for supplying refrigerant of the circuit section 28A (discharge pressure zone) to the control pressure chamber 121. Together with the passage 58, the shared passage 78, the accommodation chamber 79, and the passage 57, the second valve hole 37A forms a discharge passage for discharging refrigerant of the control pressure chamber 121 to the suction chamber 131 (suction pressure zone).

[0100] The displacement control valve 32A is a control valve of a valve opening degree changing type, which changes the electromagnetic force (duty ratio), thereby continuously varying the flow passage areas of the first valve hole 36A and the second valve hole 37A.

[0101] The sixth embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment. Further, the sixth embodiment provides the following advantages.

(6-1) The distance between the first valve body 39A and the second valve body 40A is changed according to the displacement of the transmission rod 45A. This configuration, in which the distance is changeable, permits the second valve body 40A to be located at the closing position for closing the second valve hole 37A (specific position) when the transmission rod 45A is in the predetermined displacement range [W3, W4]. This configuration, in which the distance is changeable, is suitable for realizing the double closing state, in which the first valve body 39A closes

the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A when the transmission rod 45A is in the predetermined displacement range [W3, W4].
When the transmission rod 45A is outside of the displacement range [W3, W4], and the step 456 is not contacting the second valve body 40A, the second valve body 40A closes the second valve hole 37A by means of the force of the compression spring 82. The step 456 for separating the second valve body 40A from the closing position for closing the second valve hole 37A, and a distance changing mechanism having the compression spring 82 for causing the second valve body 40A to contact the seating face 771, are suitable as means for changing the distance between the first valve body 39A and the second valve body 40A according to the position of the transmission rod 45A.

(6-2) When the transmission rod 45A is in the predetermined displacement range [W3, W4], the first valve body 39A is in the first valve hole 36A to close the first valve hole 36A. The configuration in which the first valve body 39A fixed to the transmission rod 45A is caused to enter and close the first valve hole 36A is a simplified configuration for closing the first valve hole 36A when the transmission rod 45A is in the predetermined displacement range [W3, W4].

(6-3) If the flow passage area of the first valve hole 36A, which is a part of the supply passage, is finely changed, the compressor displacement can be finely controlled. The first valve body 39A has the tapered portion 395, which is selectively inserted into the first valve hole 36A. The tapered portion 395 is a favorable structure for finely changing the flow passage area of the first valve hole 36A according to the position of the first valve body 39A when the first valve body 39A is in the first valve hole 36A. The tapered portion 395 is advantageous for permitting the cylindrical portion 394 outside of the first valve hole 36A to smoothly enter the first valve hole 36A.

(6-4) Since the first valve body 39A is integrated with the transmission rod 45A, the number of the components is reduced, and the valve mechanism is simplified.

[0102] A seventh embodiment will now be described with reference to Figs. 11(a) and 11(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the sixth embodiment shown in Figs. 9 and 10.

[0103] The first valve hole 36A and the second valve hole 37A are separated from each other by a separation portion 83, which is a separation member, formed on the circumference of the transmission rod 45A. The first valve hole 36A communicates with the control pressure chamber 121 through a passage 65, and the second valve hole 37A communicates with the control pressure chamber 121 through a passage 66. The distance H4 between the step 456 and the boundary 396 is less than the distance K4 between the open end 362 of the first valve hole 36A and the seating face 771.

[0104] When the cylindrical portion 394 of the first valve body 39A is out of the first valve hole 36A, refrigerant in the pressure sensing chamber 49 flows into the control pressure chamber 121 through the first valve hole 36A and the passage 65. When the second valve body 40A is separated from the seating face 771, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 66, the second valve hole 37A, the accommodation chamber 79, and the passage 57. When the transmission rod 45A is in the predetermined displacement range [W3, W4] (see Fig. 10(b)), the first valve body 39A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A.

[0105] The seventh embodiment thus provides the same advantages as the sixth embodiment.

[0106] An eighth embodiment will now be described with reference to Figs. 12(a), 12(b), 12(c), 13(a), 13(b), and 13 (c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the sixth embodiment shown in Figs. 9 and 10.

[0107] As shown in Fig. 12(a), a first valve body 67A is accommodated in the pressure sensing chamber 49. The first valve body 67A is slidably fitted around the transmission rod 45A. A step 457 is formed on the transmission rod 45A. The first valve body 67A selectively contacts the step 457.

[0108] A second valve body 68A is integrally formed with (fixed to) the transmission rod 45A. The second valve body 68A includes a cylindrical portion 684 and a tapered portion 685. The diameter of the tapered portion 685 is increased in a direction from the first valve hole 36A to the second valve hole 37A. The cylindrical portion 684 of the second valve body 68A is configured to enter and close the second valve hole 37A, while the first valve body 67A is configured to contact a seating face 772 of the valve hole forming portion 77 and close the first valve hole 36A.

[0109] A compression spring 84 is located between the end wall 51 and the first valve body 67A. The compression spring 84 urges the first valve body 67A toward a closing position at which the first valve body 67A closes the first valve hole 36A (a position where the first valve body 67A contacts the seating face 772). The first valve body 67A is urged toward the step 457 by the force of the compression spring 84.

[0110] A distance H5 (see Fig. 12(b)) between the step 457 and a boundary 686 between the cylindrical portion 684 of the second valve body 68A and the tapered portion 685 is less than a distance K5 (see Fig. 12(b)) between an open end 372 of the second valve hole 37A and the seating face 772.

[0111] In Figs. 12(a) and 12(b), the duty ratio is set to 100% in the control of current to the solenoid 41A. In this state, the step 457 of the transmission rod 45A is separated from the first valve body 67A, and the first valve body 67A contacts the seating face 772. That is, the first valve hole 36A is closed. On the other hand, the cylindrical portion 684 of the second valve body 68A is out of the second valve hole 37A so that the second valve hole 37A is open. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 (see Fig. 1) is maximized. Accordingly, the variable displacement compressor 10 (see Fig. 1) operates at the maximum displacement.

[0112] In the state of Fig. 12(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. In this state, the step 457 of the transmission rod 45A is separated from the first valve body 67A, and the first valve hole 36A is closed by the first valve body 67A. On the other hand, the cylindrical portion 684 of the second valve body 68A is out of the second valve hole 37A so that the second valve hole 37A is open. The opening degree of the second valve hole 37A in the state of Fig. 12(c) is less than that in the state of Fig. 12(b). In the state of Fig. 12(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0113] In the state of Fig. 13(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 12(c). In the illustrated state, the step 457 of the transmission rod 45A is separated from the first valve body 67A, and the cylindrical portion 684 of the second valve body 68A is in the second valve hole 37A (the boundary 686 is in the second valve hole 37A). The first valve body 67A is in a position where it contacts the seating face 772 (a closing position for the first valve hole 36A). That is, the first valve hole 36A is closed by the first valve body 67A.

[0114] In the state of Fig. 13(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 13(a). In the illustrated state, the step 457 of the transmission rod 45A contacts the first valve body 67A, and the cylindrical portion 684 of the second valve body 68A is in the second valve hole 37A (the boundary 686 is in the second valve hole 37A). The first valve body 67A is in a position where it contacts the seating face 772 (a closing position for closing the first valve hole 36A). That is, the first valve hole 36A is closed by the first valve body 67A.

[0115] In either of the states shown in Figs. 13(a) and 13(b), the cylindrical portion 684 of the second valve body 68A is in the second valve hole 37A, and the first valve body 67A is in a closing position for closing the first valve hole 36A. As the electromagnetic force of the solenoid 41A is reduced from the state of Fig. 13(a) (a state in which the end face 455 of the transmission rod 45A is in a position W3), the end face 455 of the transmission rod 45A is moved away from the first valve hole 36A, so that the step 457 approaches the first valve body 67A. As the electromagnetic force of the solenoid 41A is increased from the state of Fig. 13(b) (a state in which the end face 455 of the transmission rod 45A is in a position W4), the end face 455 of the transmission rod 45A is moved from the position W4 toward the position W3, and the step 457 is separated from the first valve body 67A.

[0116] The displacement range [W3, W4] is a predetermined range of a double closing state of the transmission rod 45A, in which the first valve body 67A closes the first valve hole 36A, and the second valve body 68A closes the second valve hole 37A. When the transmission rod 45A, which is a reciprocating body, is in the predetermined displacement range [W3, W4], the double closing state occurs, in which the first valve body 67A closes the first valve hole 36A, and the second valve body 68A closes the second valve hole 37A. This state is obtained because the distance H5 between the step 457 and the boundary 686 is less than the distance K5 between the seating face 772 and the open end 372 of the second valve hole 37A.

[0117] If the duty ratio is further reduced from the state of Fig. 13(b), the state shown in Fig. 13(c) is obtained (including a case where the duty ratio is zero). The step 457 of the transmission rod 45A contacts the first valve body 67A, and the first valve body 67A is in the position where it is separated from the seating face 772 (the position opening the first valve hole 36A). On the other hand, the cylindrical portion 684 of the second valve body 68A is in the second valve hole 37A so that the second valve hole 37A is closed. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0118] The opening degree of the first valve hole 36A is determined by the balance of the electromagnetic force produced by the solenoid 41A, the force of the urging spring 80, the force of the compression spring 84, and the force of the pressure sensing member 54A. The opening degree of the second valve hole 37A is determined by the balance of the electromagnetic force produced by the solenoid 41A, the force of the urging spring 80, and the force of the pressure sensing member 54A.

[0119] The eighth embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment. Further, the eighth embodiment provides the following advantages.

(8-1) The distance between the first valve body 67A and the second valve body 68A is changed according to the displacement of the transmission rod 45A. This configuration, in which the distance is changeable, permits the first valve body 67A to be located at the closing position for closing the first valve hole 36A (specific position) when the transmission rod 45A is in the predetermined displacement range [W3, W4]. This configuration, in which the distance

is changeable, is suitable for realizing the double closing state, in which the first valve body 67A closes the first valve hole 36A, and the second valve body 68A closes the second valve hole 37A when the transmission rod 45A is in the predetermined displacement range [W3, W4].
When the transmission rod 45A is outside of the displacement range [W3, W4], and the step 457 is not contacting the first valve body 67A, the first valve body 67A closes the first valve hole 36A by means of the force of the compression spring 84. The step 457 for separating the first valve body 67A from the closing position for closing the first valve hole 36A, and a distance changing mechanism having the compression spring 84 for causing the first valve body 67A to contact the seating face 772, are suitable as means for changing the distance between the first valve body 67A and the second valve body 68A according to the position of the transmission rod 45A.

(8-2) When the transmission rod 45A is in the predetermined displacement range [W3, W4], the second valve body 68A is in the second valve hole 37A to close the second valve hole 37A. The configuration in which the second valve body 68A fixed to the transmission rod 45A is caused to enter and close the second valve hole 37A is a simplified configuration for closing the second valve hole 37A when the transmission rod 45A is in the predetermined displacement range [W3, W4].

(8-3) If the flow passage area of the second valve hole 37A, which is a part of the discharge passage, is finely changed, the compressor displacement can be finely controlled. The second valve body 68A has the tapered portion 685, which is selectively inserted into the second valve hole 37A. The tapered portion 685 is a favorable structure for finely changing the flow passage area of the second valve hole 37A according to the position of the second valve body 68A when the second valve body 37A is in the second valve hole 37A. The tapered portion 685 is advantageous for permitting the cylindrical portion 684 outside of the second valve hole 37A to smoothly enter the second valve hole 37A.

(8-4) Since the second valve body 68A is integrated with the transmission rod 45A, the number of the components is reduced, and the valve mechanism is simplified.

[0120] A ninth embodiment will now be described with reference to Fig. 14. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the eighth embodiment shown in Figs. 12 and 13.

[0121] The first valve hole 36A and the second valve hole 37A are separated from each other by a separation portion 83 formed on the circumference of the transmission rod 45A. The first valve hole 36A communicates with the control pressure chamber 121 through a passage 65, and the second valve hole 37A communicates with the control pressure chamber 121 through a passage 66. The distance H5 between the step 457 and the boundary 686 is less than the distance K5 between the seating face 772 and the open end 372 of the second valve hole 37A. When the transmission rod 45A is in the predetermined displacement range [W3, W4] (see Fig. 12(b)), the first valve body 67A closes the first valve hole 36A, and the second valve body 68A closes the second valve hole 37A.

[0122] The ninth embodiment thus provides the same advantages as the eighth embodiment.

[0123] A tenth embodiment will now be described with reference to Figs. 15(a) and 15(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the sixth embodiment shown in Figs. 9 and 10 and the eighth embodiment shown in Figs. 12 and 13.

[0124] In the tenth embodiment, the first valve body 39A of the sixth embodiment and the second valve body 68A of the eighth embodiment are used together. That is, the first valve body 39A and the second valve body 68A are both integrally formed with (fixed to) the transmission rod 45A. A distance H6 between the boundary 396 of the first valve body 39A and the boundary 686 of the second valve body 68A is less than a distance K6 between the open end 362 of the first valve hole 36A and the open end 372 of the second valve hole 37A.

[0125] When the transmission rod 45A is in the predetermined displacement range [W3, W4], a double closing state occurs, in which the first valve body 39A is in the first valve hole 36A and closes the first valve hole 36A, and the second valve body 68A is in the second valve hole 37A and closes the second valve hole 37A. When the transmission rod 45A is in the predetermined displacement range [W3, W4], the valve bodies 39A, 68A fixed to the transmission rod 45 are in positions closing the valve holes 36A, 37A. When the transmission rod 45A is moved from the inside of the predetermined displacement range [W3, W4] to the outside of the displacement range [W3, W4], one of the valve bodies 39A, 68A opens the corresponding valve hole (36A or 37A), and the other valve body closes the corresponding valve hole (37A or 36A).

[0126] The tenth embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment, advantages (6-1) to (6-4) of the sixth embodiment, and the advantages (8-1) to (8-4) of the eighth embodiment.

[0127] An eleventh embodiment will now be described with reference to Figs. 16(a), 16(b), 16(c), 17(a), 17(b), and 17(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c) and the third embodiment shown in Figs. 5(a) to 6(c).

[0128] As shown in Fig. 16(a), a pair of valve seats 85, 35 are formed in a valve housing 33 that forms part of a displacement control valve 32. A first valve hole 36 is formed in the valve seat 85, and a second valve hole 37 is formed in the valve seat 35. The transmission rod 45 extends through the chamber 46 and the second valve hole 37.

[0129] A shared chamber 38 is defined between the valve seat 85 and the valve seat 35 (between the first valve hole 36 and the second valve hole 37). A first valve body 67 and a second valve body 40 are accommodated in the shared chamber 38. The first valve body 67 and the second valve body 40 are slidably fitted around the transmission rod 45. The first valve body 67 is configured to contact the valve seat 85 and close the first valve hole 36, while the second valve body 40 is configured to contact the valve seat 35 and close the second valve hole 37.

[0130] An auxiliary rod 87 is attached to the movable body 52 of the pressure sensing member 54 at a coupling face 872. An end face 871 of the auxiliary rod 87 always contacts an end face 452 of the transmission rod 45. The diameter of the end face 871 of the auxiliary rod 87, which forms a reciprocating body with the transmission rod 45, is greater than the diameter of the end face 452 of the transmission rod 45. The end face 871, which functions as a first displacement transmission portion, selectively contacts the first valve body 67. The end face 871 contacts the second valve body 40 to transmit displacement of the transmission rod 45, thereby moving the second valve body 40, which functions as a sliding valve body, from the closing position to the opening position.

[0131] A compression spring 99 is located between the first valve body 67 and the valve seat 35, and a compression spring 86 is located between the first valve body 67 and the second valve body 40. The compression spring 99 urges the first valve body 67 toward a closing position at which the first valve body 67 closes the first valve hole 36 (a position where the first valve body 67 contacts the valve seat 85). The compression spring 86 urges the first valve body 67 toward a closing position at which the first valve body 67 closes the first valve hole 36 (a position where the first valve body 67 contacts the valve seat 85). The compression spring 86 also urges the second valve body 40 toward a closing position at which the second valve body 40 closes the second valve hole 37 (a position where the second valve body 67 contacts the valve seat 35). The first valve body 67 is urged toward the end face 871 by the force of the compression spring 99. The second valve body 40 is urged toward the step 451, which functions as a second displacement transmission portion, by the force of the compression spring 86. The compression spring 99 functions as a first urging member that urges the first valve body 67 toward a position at which the first valve body 67 contacts the end face 871. The compression spring 86 functions as a second urging member that urges the second valve body 40 toward a position at which the second valve body 40 contacts the step 451.

[0132] The displacement control valve 32 has a seating face 851 in which the first valve hole 36 opens and a seating face 351 in which the second valve hole 37 opens. A distance K7 between the seating face 851 of the valve seat 85 and the seating face 351 of the valve seat 35 is less than a distance H7 (shown in Fig. 16(b)) between the end face 871 and the step 451. That is, to ensure that the predetermined displacement range [W1, W2] be created, the distance K7 between the seating faces 851, 351 is different from the distance H7 between the first displacement transmission portion (end face 871) and the second displacement transmission portion (the step 451).

[0133] In Figs. 16(a) and 16(b), the duty ratio is set to 100% in the control of current to the solenoid 41. In this state, the end face 871 is separated from the first valve body 67, and the step 451 contacts the second valve body 40. That is, the first valve hole 36 is open, and the second valve hole 37 is closed. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 (see Fig. 1) is maximized. Accordingly, the variable displacement compressor 10 (see Fig. 1) operates at the maximum displacement.

[0134] In the state of Fig. 16(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. The end face 871 is separated from the first valve body 67, and the first valve body 67 contacts the seating face 851. The step 451 contacts the second valve body 40, and the second valve body 40 is separated from the seating face 351. That is, the first valve hole 36 is closed, and the second valve hole 37 is open. The opening degree of the second valve hole 37 in the state of Fig. 16(c) is less than that in the state of Fig. 16(b). In the state of Fig. 16(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0135] In the state of Fig. 17(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 16(c). In the illustrated state, the end face 871 is separated from the first valve body 67, and the step 451 contacts the second valve body 40. The first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37.

[0136] In the state of Fig. 17(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 17(a). In the illustrated state, the end face 871 contacts the first valve body 67, and the step 451 is separated from the second valve body 40. The first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37.

[0137] As the electromagnetic force of the solenoid 41 is reduced from the state of Fig. 17(a) (a state in which the coupling face 872 of the auxiliary rod 87 is in a position W5), the end face 871 of the auxiliary rod 87 approaches the first valve body 67, and the step 451 is separated from the second valve body 40. As the electromagnetic force of the solenoid 41 is increased from the state of Fig. 17(b) (a state in which the coupling face 872 of the auxiliary rod 87 is in a position W6), the end face 871 of the auxiliary rod 87 is separated from the first valve body 67, and the step 451 approaches the second valve body 40.

[0138] The displacement range [W5, W6] is a predetermined range of a double closing state of the transmission rod 45, in which the first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37. When the transmission rod 45, which is a reciprocating body, is in the predetermined displacement range [W5, W6], the double closing state occurs, in which the first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37. This state is obtained because the distance H7 between the end face 871 and the step 451 is greater than the distance K7 between the seating face 851 and the seating face 351.

[0139] If the duty ratio is further reduced from the state of Fig. 17(b), the state shown in Fig. 17(c) is obtained (including a case where the duty ratio is zero).

[0140] The end face 871 contacts the first valve body 67, and the first valve body 67 is in the position where it is separated from the seating face 851 (the position opening the first valve hole 36). On the other hand, the step 451 is separated from the second valve body 40 so that the second valve hole 37 is closed. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0141] The eleventh embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment. Further, the eleventh embodiment provides the following advantage.

(11-1) The distance between the first valve body 67 and the second valve body 40 is changed according to the displacement of the transmission rod 45. This configuration, in which the distance is changeable, permits a state to be realized, in which the first valve body 67 is at a closing position (specific position) for closing the first valve hole 36, and the second valve body 40 is at a closing position (specific position) for closing the second valve hole 37 when the transmission rod 45 is in the predetermined displacement range [W5, W6]. This configuration, in which the distance is changeable, is suitable for realizing the double closing state, in which the first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37 when the transmission rod 45 is in the predetermined displacement range [W5, W6].

When the transmission rod 45 is outside of the displacement range [W5, W6], and the end face 871 of the auxiliary rod 87 is not contacting the first valve body 67, the first valve body 67 closes the first valve hole 36 by means of the force of the compression spring 99. When the transmission rod 45 is outside of the displacement range [W5, W6], and the step 451 is not contacting the second valve body 40, the second valve body 40 closes the second valve hole 37 by means of the force of the compression spring 86. The end face 871 for separating the first valve body 67 from the closing position for closing the first valve hole 36, the step 451 for separating the second valve body 40 from the closing position for closing the second valve hole 37, and a distance changing mechanism having the compression springs 86, 99 are suitable as means for changing the distance between the first valve body 67 and the second valve body 40 according to the position of the transmission rod 45.

[0142] A twelfth embodiment will now be described with reference to Figs. 18(a) and 18(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the eleventh embodiment shown in Figs. 16 and 17.

[0143] A first chamber 88 and a second chamber 64 are defined by a separation member 62 between the valve seat 85 and the valve seat 35. The first chamber 88 is connected to the first valve hole 36, and the second chamber 64 is connected to the second valve hole 37. The first chamber 88 communicates with the control pressure chamber 121 through a passage 65, and the second chamber 64 communicates with the control pressure chamber 121 through a passage 66. A compression spring 71 located between the valve seat 85 and the separation member 62 urges the first valve body 67 toward the valve seat 85. A compression spring 47 located between the separation member 62 and the second valve body 40 urges the second valve body 40 toward the valve seat 35. A distance H7 between the end face 871 and the step 451 is greater than a distance K7 between the seating face 851 and the seating face 351. When the transmission rod 45 is in the predetermined displacement range [W5, W6], the first valve body 67 closes the first valve hole 36, and the second valve body 40 closes the second valve hole 37.

[0144] The twelfth embodiment has the same advantages as the advantages (1-1) and (1-4) of the first embodiment. Further, the twelfth embodiment provides the following advantage.

(12-1) When the transmission rod 45 is outside of the displacement range [W5, W6], and the end face 871 of the auxiliary rod 87 is not contacting the first valve body 67, the first valve body 67 closes the first valve hole 36 by means of the force of the compression spring 71. When the transmission rod 45 is outside of the displacement range [W5, W6], and the step 451 is not contacting the second valve body 40, the second valve body 40 closes the second valve hole 37 by means of the force of the compression spring 47. The end face 871 for separating the first valve body 67 from the closing position for closing the first valve hole 36, the step 451 for separating the second valve body 40 from the closing position for closing the second valve hole 37, and a distance changing mechanism having the compression springs 71, 47 are suitable as means for changing the distance between the first valve body 67 and the second valve body 40 according to the position of the transmission rod 45. When the first valve body 67 closes the first valve hole 36 at a specific position, the distance changing mechanism permits the transmission rod 45 to be displaced relative to the first valve body 67 at the specific position. When the second valve body 40 closes the second valve hole 37 at a specific position, the distance changing mechanism permits the transmission rod 45 to be displaced relative to the second valve body 40 at the specific position..

[0145] A thirteenth embodiment will now be described with reference to Figs. 19(a), 19(b), 19(c), 20(a), 20(b), and 20 (c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the sixth embodiment shown in Figs. 9 and 10 and the eighth embodiment shown in Figs. 12 and 13.

[0146] As shown in Figs. 19(a) and 19(b), a first valve body 67A is accommodated in the pressure sensing chamber 49. The first valve body 67A is slidably fitted around the transmission rod 45A. The first valve body 67A is configured to contact the seating face 772 formed on the valve hole forming portion 77 to close the first valve hole 36A. A step 457 is formed on the transmission rod 45A. The first valve body 67A selectively contacts the step 457. A second valve body 40A is accommodated in the accommodation chamber 79. The second valve body 40A is slidably fitted around the transmission rod 45A. The second valve body 40A is configured to contact the seating face 771 formed on the valve hole forming portion 77 to close the second valve hole 37A.

[0147] A compression spring 84 is located between the end wall 51 and the first valve body 67A. The compression spring 84 urges the first valve body 67A toward a closing position at which the first valve body 67A closes the first valve hole 36A (a position where the first valve body 67A contacts the seating face 772). The first valve body 67A is urged toward the step 457 by the force of the compression spring 84, which functions as a first urging member.

[0148] A compression spring 82 is located between a spring seat 81 and the second valve body 40A. The compression spring 82, which functions as a second urging member, urges the second valve body 40A toward a closing position at which the second valve body 40A closes the second valve hole 37A (a position where the second valve body 40A contacts the seating face 771). A step 456 is formed on the transmission rod 45A. The second valve body 40A selectively contacts the step 456. The second valve body 40A is urged toward the step 456 by the force of the compression spring 82.

[0149] A distance H8 (shown in Fig. 19(b)) between the step 457 and the step 456 is less than a distance K8 (shown in Fig. 19(b)) between the seating face 772 and the seating face 771.

[0150] In Figs. 19(a) and 19(b), the duty ratio is set to 100% in the control of current to the solenoid 41A. In this state, the step 457 is separated from the first valve body 67A, and the step 456 contacts the second valve body 40A. That is, the first valve hole 36A is closed, and the second valve hole 37A is open. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 (see Fig. 1) is maximized. Accordingly, the variable displacement compressor 10 (see Fig. 1) operates at the maximum displacement.

[0151] In the state of Fig. 19(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. The step 457 is separated from the first valve body 67A, and the step 456 contacts the second valve body 40A. That is, the first valve hole 36A is closed, and the second valve hole 37A is open. The opening degree of the second valve hole 37 in the state of Fig. 19(c) is less than that in the state of Fig. 19(b). In the state of Fig. 19(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0152] In the state of Fig. 20(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 19(c). In the illustrated state, the step 457 is separated from the first valve body 67A, and the step 456 contacts the second valve body 40A. The first valve body 67A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A.

[0153] In the state of Fig. 20(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 20(a). In the illustrated state, the step 457 contacts the first valve body 67A, and the step 456 is separated from the second valve body 40A. The first valve body 67A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A.

[0154] As the electromagnetic force of the solenoid 41A is reduced from the state of Fig. 20(a) (a state in which the end face 455 of the transmission rod 45A is in a position W7), the step 457 approaches the first valve body 67A, and the step 456 is separated from the second valve body 40A. As the electromagnetic force of the solenoid 41A is increased from the state of Fig. 20(b) (a state in which the end face 455 of the transmission rod 45A is in a position W8), the step 457 is separated from the first valve body 67A, and the step 456 approaches the second valve body 40A.

[0155] The displacement range [W7, W8] is a predetermined range of a double closing state of the transmission rod 45A, in which the first valve body 67A closes the first valve hole 36A, and the second valve body 68A closes the second valve hole 37A. When the transmission rod 45A, which is a reciprocating body, is in the predetermined displacement range [W7, W8], the double closing state occurs, in which the first valve body 67A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A. This state is obtained because the distance H8 between the step 457 and the step 456 is less than the distance K8 between the seating face 772 and the seating face 771.

[0156] If the duty ratio is further reduced from the state of Fig. 20(b), the state shown in Fig. 20(c) is obtained (including a case where the duty ratio is zero). The step 457 contacts the first valve body 67A, and the first valve body 67A is in the position where it is separated from the seating face 772 (the position opening the first valve hole 36A). The step 456 is separated from the second valve body 40A so that the second valve hole 37A is closed. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0157] The thirteenth embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment. Further, the thirteenth embodiment provides the following advantage.

(13-1) When the transmission rod 45A is outside of the displacement range [W7, W8], and the step 457 is not contacting the first valve body 67A, the first valve body 67A closes the first valve hole 36A by means of the force of the compression spring 84. When the transmission rod 45A is outside of the displacement range [W7, W8], and the step 456 is not contacting the second valve body 40A, the second valve body 40A closes the second valve hole 37A by means of the force of the compression spring 82. The step 457 for separating the first valve body 67A from the closing position for closing the first valve hole 36A, the step 456 for separating the second valve body 40A from the closing position for closing the second valve hole 37A, and a distance changing mechanism having the compression springs 84, 82 are suitable as means for changing the distance between the first valve body 67A and the second valve body 40A according to the position of the transmission rod 45A.

[0158] A fourteenth embodiment will now be described with reference to Fig. 21. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the thirteenth embodiment shown in Figs. 19 and 20.

[0159] The first valve hole 36A and the second valve hole 37A are separated from each other by a separation portion 83 formed on the circumference of the transmission rod 45A. The first valve hole 36A communicates with the control pressure chamber 121 through a passage 65, and the second valve hole 37A communicates with the control pressure chamber 121 through a passage 66. A distance H8 between the step 457 and the step 456 is less than a distance K8 between the seating face 772 and the seating face 771.

[0160] When the transmission rod 45A is in the predetermined displacement range [W7, W8], the first valve body 67A closes the first valve hole 36A, and the second valve body 40A closes the second valve hole 37A.

[0161] The fourteenth embodiment thus provides the same advantages as the thirteenth embodiment.

[0162] A fifteenth embodiment will now be described with reference to Figs. 22(a) and 22(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the eleventh embodiment shown in Figs. 16 and 17 and the thirteenth embodiment shown in Figs. 19 and 20.

[0163] A first valve body 89 and a second valve body 90 are accommodated in a shared chamber 38 of a displacement control valve 32B. The first valve body 89 and the second valve body 90 are slidably fitted around a transmission rod 45B. The first valve body 89 is configured to contact a valve seat 91 and close a first valve hole 92, while the second valve body 90 is configured to contact a valve seat 93 and close a second valve hole 94. The first valve body 89 has a valve closing face 893, and the valve body 90 has a valve closing face 903.

[0164] A compression spring 95 is located between the first valve body 89 and the second valve body 90. The compression spring 95 urges the first valve body 89 toward a closing position at which the first valve body 89 closes the first valve hole 92 (a position where the first valve body 89 contacts the valve seat 91). The compression spring 86 also urges the second valve body 90 toward a closing position at which the second valve body 90 closes the second valve hole 94 (a position where the second valve body 90 contacts the valve seat 93).

[0165] The auxiliary rod 87 extends through the valve seat 93 and projects into the second valve hole 94. The end face 871 of the auxiliary rod 87 always contacts an end face 452 of the transmission rod 45B.

[0166] A distance K9 between a seating face 911 of the valve seat 91 and a seating face 931 of the valve seat 93 is less than a distance H9 between the end face 871 of the auxiliary rod 87 and the step 451.

[0167] The shared chamber 38 communicates with the control pressure chamber 121 through a passage 58. The chamber 46 communicates with the circuit section 28B through the passage 97. The chamber 46 communicates with a back pressure space 98 between the movable iron core 44A and the fixed iron core 42A through a passage 441. A diameter D1 of a portion of the transmission rod 45B that is in the chamber 46 and a diameter D2 of the auxiliary rod 87 is substantially equal to each other (D1 = D2).

[0168] When the coupling face 872 of the auxiliary rod 87 is in a predetermined displacement range [W9, W10], the double closing state occurs, in which the first valve body 89 closes the first valve hole 92, and the second valve body 90 closes the second valve hole 94. This state is obtained because the distance H9 between the seating face 911 of the valve seat 91 and the seating face 931 of the valve seat 93 is less than the distance H9 between the end face 871 of the auxiliary rod 87 and the step 451. When the coupling face 872 of the auxiliary rod 87 is out of the displacement range [W9, W10], and the second valve hole 94 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 58, the shared chamber 38, the second valve hole 94, and the passage 96. When the coupling face 872 of the auxiliary rod 87 is out of the displacement range [W9, W10], and the first valve hole 92 is open, refrigerant in the circuit section 28B flows into the control pressure chamber 121 through the passage 97, the chamber 46, the first valve hole 92, the shared chamber 38, and the passage 58.

[0169] The fifteenth embodiment has the same advantages as the advantages (1-1) and (1-5) of the first embodiment, and the advantage (11-1) of the eleventh embodiment.

[0170] A load F1 acts on the transmission rod 45B by the pressure of refrigerant in the back pressure space 98, which is a first discharge pressure chamber, and a load F2 acts on the auxiliary rod 87 by the pressure of refrigerant in the pressure sensing chamber 48, which is a second discharge pressure chamber. The loads F1, F2 act against each other through the transmission rod 45B in between. In other words, the transmission rod 45 has a first end (the lower end of the rod 45) that extends through the first valve hole 92 and receives the pressure of the first discharge pressure chamber (the back pressure space 98), and a second end (the upper end of the rod 45) that extends through the second valve hole 94 and receives the pressure of the second discharge pressure chamber (the pressure sensing chamber 48). The pressure of the first discharge pressure chamber (the back pressure space 98) acts against the pressure of the second discharge pressure chamber (the pressure sensing chamber 48) through the transmission rod 45. The pressure in the pressure sensing chamber 48 and in the back pressure space 98 is the same as the pressure in the circuit section 28B. Since the diameter D1 of a portion of the transmission rod 45B that is in the chamber 46 and the diameter D2 of the auxiliary rod 87 is substantially equal to each other, the loads F1 and F2 cancel each other. This configuration, in which the loads cancel each other, is effective for preventing the accuracy of the position control of the transmission rod 45B from deteriorating due to fluctuations of the discharge pressure. That is, the configuration effectively prevents deterioration of the control accuracy of the opening degrees of the first valve hole 92 and the second valve hole 94. The variable displacement compressor 10 uses carbon dioxide, the pressure of which can be significantly higher than that of chlorofluorocarbon gas. The configuration, which permits the loads to cancel each other, is suitable for compressors like the compressor 10, which use carbon dioxide.

[0171] A sixteenth embodiment will now be described with reference to Figs. 27(a), 27(b), 27(c), 27(b), 28(a), 28(b), and 28(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c), the third embodiment shown in Figs. 5(a) to 6 (c), and the fifth embodiment shown in Fig 8.

[0172] As shown in Fig. 27(a), a discharge pressure introducing chamber 103 is defined in the valve housing 33. The discharge pressure introducing chamber 103 communicates with a section 28C of the external refrigerant circuit 28 between the discharge chamber 132 and the heat exchanger 29 through a passage 53C. A spring seat 101 and a first urging spring 102 are accommodated in the discharge pressure introducing chamber 103. The first urging spring 102 is located between the spring seat 101 and the end wall 51.

[0173] The end face 452 of the transmission rod 45 contacts the spring seat 101. The first urging spring 102 urges the transmission rod 45, which has the first valve body 39 and the second valve body 68, in a direction from the first valve hole 36 to the second valve hole 37. The transmission rod 45 is urged in a direction from the first valve hole 36 to the second valve hole 37 by the urging spring 56 (hereinafter, referred to as a second urging spring 56).

[0174] The chamber 46 communicates with a space 104 between the movable iron core 44 and the fixed iron core 42 through a passage 421. The chamber 46 communicates with a back pressure space 98A at the back of the movable iron core 44 through the passages 421 and 442.

[0175] The pressure in the discharge pressure introducing chamber 103 is equal to the pressure in the circuit section 28C (discharge pressure). The pressure in the space 104 and the pressure in the back pressure space 98A correspond to the pressure in the suction chamber 131 (suction pressure). The chamber 46, the space 104, and the back pressure space 98A form a suction pressure introducing chamber of a pressure zone that corresponds to the suction pressure. The discharge pressure introducing chamber 103 and the suction pressure introducing chamber are arranged with the first and second valve holes 36, 37 in between. One end of the transmission rod 45 extends through the first valve hole 36 and receives the pressure in the discharge pressure introducing chamber 103. The other end of the transmission rod 45 extends through the second valve hole 37 and receives the pressure in the suction pressure introducing chamber.

[0176] A diameter D3 of the cylindrical portion 391 of the first valve body 39 is equal to a diameter D4 of the cylindrical portion 681 of the second valve body 68 (D3 = D4). That is, the diameter of the first valve hole 36 is equal to the diameter of the second valve hole 37. The transmission rod 45 receives a load F3 in a direction from the second valve hole 37 to the first valve hole 36 due to the suction pressure. The load F3 is obtained by multiplying the cross-sectional area of the first and second valve bodies 39, 68 by the suction pressure. The transmission rod 45 also receives a load F4 in a direction from the first valve hole 36 to the second valve hole 37 due to the discharge pressure in the discharge pressure introducing chamber 103. The load F4 is obtained by multiplying the cross-sectional area of the first and second valve bodies 39, 68 by the discharge pressure. That is, the load F3, which is applied to the transmission rod 45 by the suction pressure in a direction from the second valve hole 37 to the first valve hole 36, and the load F4, which is applied to the transmission rod 45 by the refrigerant pressure in the discharge pressure introducing chamber 103 in a direction from the first valve hole 36 to the second valve hole 37, oppose each other with the transmission rod 45 in between. Therefore, the transmission rod 45 is urged in a direction from the first valve hole 36 to the second valve hole 37 by the load difference (F4 - F3). That is, the load difference (F4 - F3) acts against the electromagnetic force of the solenoid 41.

[0177] The opening degrees of the first and second valve holes 36, 37 are determined by the balance of the electromagnetic force produced by the solenoid 41, the force of the first urging spring 102, the force of the second urging spring 56, and the force of the load difference (F4 - F3). When the difference between the discharge pressure and the suction pressure is increased, the load difference (F4 - F3) is increased, accordingly. When the difference between the discharge pressure and the suction pressure is reduced, the load difference (F4 - F3) is reduced, accordingly. When the load difference (F4 - F3) is increased, the transmission rod 45 is displaced in a direction from the first valve hole 36 to the second valve hole 37. When the load difference (F4 - F3) is reduced, the transmission rod 45 is displaced in a direction from the second valve hole 37 to the first valve hole 36.

[0178] In Figs. 27(a) and 27(b), the duty ratio is set to 100% in the control of current to the solenoid 41. The cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the shared chamber 38 through the first valve hole 36. Also, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. On the other hand, the cylindrical portion 681 of the second valve body 68 is out of the second valve hole 37 so that the second valve hole 37 is open. Since the second valve hole 37 is open, refrigerant in the shared chamber 38 flows out to the suction chamber 131 through the second valve hole 37, the chamber 46, and the passage 57. That is, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57.

[0179] That is, in the state shown in Figs. 27(a) and 27(b), a displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121, while permitting refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is reduced, and the inclination angle of the swash plate 22 (see Fig. 1) is maximized. Accordingly, the variable displacement compressor 10 (see Fig. 1) operates at the maximum displacement.

[0180] In the state of Fig. 27(c), although less than 100%, the duty ratio control is being executed at a relatively high duty ratio. In this state, the first valve hole 36 is closed, and the second valve hole 37 is open. That is, the displacement control valve 32C allows refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121. The control valve 32C also allows refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131. The opening degree of the second valve hole 37 in the state of Fig. 27(c) is less than that in the state of Fig. 27(b). In the state of Fig. 27(c), an intermediate displacement operation is performed in which the inclination angle of the swash plate 22 is less than the maximum inclination angle.

[0181] In the state of Fig. 28(a), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 27(c). In the state of Fig. 28(b), the duty ratio control is being executed at a duty ratio that is less than that of the state shown in Fig. 28(a). In either of the states shown in Figs. 28(a) and 28(b), the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36), and the first valve hole 36 is closed by the first valve body 39. Also, the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37), and the second valve hole 37 is closed by the second valve body 68.

[0182] In either of the states shown in Figs. 28(a) and 28(b), the first valve body 39 is in a position where it closes the first valve hole 36, and the second valve body 68 is in a position where it closes the second valve hole 37. If the end face 452 of the transmission rod 45 is in a displacement range [W1, W2] from the position W1 to the position W2, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36), and the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37).

[0183] The displacement range [W1, W2] is a predetermined range of a double closing state of the transmission rod 45, in which the first valve body 39 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. When the transmission rod 45, which is a reciprocating body, is in the predetermined displacement range [W1, W2], the double closing state occurs, in which the first valve body 39 closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. This state is obtained because a distance H3 between the boundary 683 and the boundary 393 is greater than a distance K3 between the open end 361 and the open end 371. That is, to ensure that the predetermined displacement range [W1, W2] be created, the distance H3 between the first initial contact portions (the boundaries 683, 393) is different from the distance K3 between the second initial contact portions (the open ends 361, 371).

[0184] In Figs. 28(a) and 28(b), since the second valve hole 37 is closed, refrigerant in the control pressure chamber

121 does not flow out to the suction chamber 131 (suction pressure zone). Also, since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Figs. 28(a) and 28(b), the displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32C also does not allow refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0185] If the duty ratio is further reduced from the state of Fig. 28(b), the state shown in Fig. 28(c) is obtained (including a case where the duty ratio is zero). In this state, this control is executed when the variable displacement compressor 10 is operated at a small displacement or when the speed of the vehicle engine E is abruptly increased while the air-conditioner switch 59 is ON.

[0186] The cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 so that the second valve hole 37 is closed. Therefore, refrigerant in the shared chamber 38 does not flow out to the chamber 46 through the second valve hole 37. That is, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the cylindrical portion 391 of the first valve body 39 is out of the first valve hole 36 so that the first valve hole 36 is open. Since the first valve hole 36 is open, refrigerant in the discharge pressure introducing chamber 103 flows into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, the displacement control valve 32C allows refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121, while preventing refrigerant in the control pressure chamber 121 from flowing out to the suction chamber 131. Therefore, the pressure in the control pressure chamber 121 is high, and the inclination angle of the swash plate 22 is minimized. Accordingly, the variable displacement compressor 10 operates at the minimum displacement.

[0187] In the state of Fig. 28(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 39 opens the first valve hole 36, and the second valve body 68 closes the second valve hole 37. In the state of Figs. 27(b) and 27(c), the transmission rod 45 is out of the predetermined displacement range [W1, W2], the first valve body 39 closes the first valve hole 36, and the second valve body 68 opens the second valve hole 37. That is, when the transmission rod 45 is out of the predetermined displacement range [W1, W2], one of the state in which the first valve body 39 closes the first valve hole 36, and the state in which the second valve body 68 closes the second valve hole 37 occurs.

[0188] In the state of Fig. 27(c) or the state of Figs. 28(a) and 28(b), if the difference between the discharge pressure and the suction pressure increases, the transmission rod 45 is displaced in a direction from the first valve hole 36 to the second valve hole 37 due to an increase in the load difference (F4 - F3). When the cylindrical portion 391 of the first valve body 39 is out of the first valve hole 36, the first valve hole 36 is open. When the first valve hole 36 is open, refrigerant in the discharge pressure introducing chamber 103 flows into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. This increases the pressure in the control pressure chamber 121, thereby reducing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is reduced.

[0189] In the state of Figs. 28(a), 28(b), and 28(c), if the difference between the discharge pressure and the suction pressure is reduced, the transmission rod 45 is displaced in a direction from the second valve hole 37 to the first valve hole 36 due to a decrease in the load difference (F4 - F3). When the cylindrical portion 681 of the second valve body 68 is out of the second valve hole 37, the second valve hole 37 is open. When the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. This reduces the pressure in the control pressure chamber 121, thereby increasing the inclination angle of the swash plate 22. Accordingly, the compressor displacement is increased.

[0190] In addition to the same advantages as the fifth embodiment, the sixteenth embodiment provides the following advantages.

(16-1) In the displacement control valve 32C, the pressure in the discharge pressure introducing chamber 103 and the pressure in the suction pressure introducing chamber oppose each other with the transmission rod 45, which functions as a reciprocating body, in between. The displacement control valve 32C thus configured only controls the pressure difference between the discharge pressure and the suction pressure. That is, the displacement control valve 32C is controlled such that the difference between the discharge pressure and the suction pressure is balanced with the electromagnetic force of the solenoid 41. Since the displacement control valve 32C does not use the pressure sensing member 54 having the bellows 50 as in the first embodiment, the displacement control valve 32C of the present embodiment has a simpler construction than the displacement control valve 32 having the pressure sensing member 54.

(16-2) The spring characteristics of the first urging spring 102 and the second urging spring 56 are set, for example, as indicated by lines E1, E2 in the graph of Fig. 27(d). A horizontal axis L represents the distance between the fixed iron core 42 and the movable iron core 44, and the vertical axis represents force. Lo represents the maximum distance between the fixed iron core 42 and the movable iron core 44. Line E1 represents the spring characteristics of the first urging spring 102, and line E2 represents the spring characteristics of the second urging spring 56. Curve G represents the electromagnetic force of the solenoid 41.
If the second urging spring 56 is not used, the spring characteristics of the first urging spring 102 need to be changed to that indicated by chain line E3. However, such spring characteristics would result in too strong a spring force. In such a case, the solenoid 41 needs to be configured to produce a greater force, or the size of the solenoid 41 needs to be increased. The combination of the first urging spring 102 and the second urging spring 56 is favorable for reliably controlling the opening degrees of the first and second valve holes 36, 37, while eliminating the necessity for increasing the size of the solenoid 41.

(16-3) The diameter D3 of the cylindrical portion 391 of the first valve body 39 is equal to the diameter D4 of the cylindrical portion 681 of the second valve body 68 (D3 = D4). That is, the diameter of the first valve hole 36 is equal to the diameter of the second valve hole 37.
If the diameter D3 of the cylindrical portion 391 of the first valve body 39 is less than the diameter D4 of the cylindrical portion 681 of the second valve body 68, the transmission rod 45 is urged in a direction from the first valve hole 36 to the second valve hole 37 by the pressure in the shared chamber 38 (control pressure introducing chamber), which corresponds to the control pressure. In contrast, if the diameter D3 of the cylindrical portion 391 of the first valve body 39 is greater than the diameter D4 of the cylindrical portion 681 of the second valve body 68, the transmission rod 45 is urged in a direction from the second valve hole 37 to the first valve hole 36 by the pressure in the shared chamber 38, which corresponds to the control pressure. That is, the opening degree control of the first and second valve holes 36, 37 is affected by the pressure in the shared chamber 38 (corresponding to the control pressure). As a result, the opening degrees of the first and second valve holes 36, 37 are not reliably controlled.
The present embodiment, in which the diameter D3 of the cylindrical portion 391 of the first valve body 39 is equal to the diameter D4 of the cylindrical portion 681 of the second valve body 68, avoids problems in the opening degree control of the first and second valve holes 36, 37 ascribable to the pressure in the shared chamber 38 (corresponding to the control pressure).

[0191] A seventeenth embodiment will now be described with reference to Figs. 29(a), 29(b), and 29(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c) and the sixteenth embodiment shown in Figs. 27 and 28.

[0192] A flange 458 is integrally formed with a circumferential surface of the transmission rod 45 in the shared chamber 38. A recess 401 is formed in a second valve body 40B. The flange 458 is inserted into the recess 401. One end face 459 of the flange 458 selectively contacts a bottom 402 of the recess 401. The bottom 402 functions as a displacement receiving face that can contact the end face 459. The bottom 402 is separated from the valve closing face 403 with respect to the direction of displacement of the transmission rod 45. The open end of the recess 401 forms the valve closing face 403. A diameter of the recess 401 is equal to a diameter D5 of the second valve hole 37, and the diameter D5 of the second valve hole 37 is greater than a diameter D6 of the first valve hole 36.

[0193] In the state of Fig. 29(a), the end face 459 of the flange 458 contacts the bottom 402, and the second valve body 40B is at an opening position separated from the seating face 351 of the valve seat 35. Since the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. On the other hand, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the shared chamber 38 through the first valve hole 36. Also, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Fig. 29(a), a displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121, while permitting refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0194] In the state of Fig. 29(b), the end face 459 of the flange 458 contacts the bottom 402. The second valve body 40B is in a position where it contacts the seating face 351 of the valve seat 35. That is, the second valve hole 37 is closed by the second valve body 40B. The cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36).

[0195] In the state of Fig. 29(c), the end face 459 of the flange 458 is separated from the bottom 402. The second valve body 40B is in a position where it contacts the seating face 351 of the valve seat 35 (a position where the second valve body 40B closes the second valve hole 37). That is, the second valve hole 37 is closed by the second valve body

40B. The cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36).

[0196] In either of the states shown in Figs. 29(b) and 29(c), the first valve body 39 is in a position where it closes the first valve hole 36, and the second valve body 40B is in a position where it closes the second valve hole 37. As the electromagnetic force of the solenoid 41 is reduced from the state of Fig. 29(b) (a state in which the end face 452 of the transmission rod 45 is in a position W1), the end face 452 of the transmission rod 45 is moved from the position W1 toward the first valve hole 36, and the end face 459 is separated from the bottom 402. As the electromagnetic force of the solenoid 41 is increased from the state of Fig. 29(c) (a state in which the end face 452 of the transmission rod 45 is in a position W2), the end face 452 of the transmission rod 45 is moved from the position W2 toward the position W1, and the end face 459 approaches the bottom 402. If the end face 452 of the transmission rod 45 is in a displacement range [W1, W2] from the position W1 to the position W2, the cylindrical portion 391 of the first valve body 39 is in the first valve hole 36 (the boundary 393 is in the first valve hole 36), and the second valve body 40B is in the position where it contacts the seating face 351 of the valve seat 35 (a position where the second valve body 40B closes the second valve hole 37).

[0197] The displacement range [W1, W2] is a predetermined range of a double closing state of the transmission rod 45, in which the first valve body 39 closes the first valve hole 36, and the second valve body 40B closes the second valve hole 37. When the transmission rod 45, which is a reciprocating body, is in the predetermined displacement range [W1, W2], the double closing state occurs, in which the first valve body 39 closes the first valve hole 36, and the second valve body 40B closes the second valve hole 37. This state is obtained because the sum of a distance H11 between the end face 459 and the boundary 393 and a depth H12 of the recess 401 (H11 + H12 = H1) is greater than the distance K1 between the open end 361 and the seating face 351. That is, to ensure that the predetermined displacement range [W1, W2] be created, the sum (H11 + H12 = H1) of the distance H11 between the displacement transmission portion (the end face 459) and the first initial contact portion (the boundary 393 of the first valve body 39) and the distance (the depth H12 of the recess 401) between the valve closing face 403 of the second valve body 40B and the displacement receiving face (the bottom 402 of the recess 401) is different from the distance K1 between the second initial contact portion (the open end 361 of the first valve hole 36) and the seating face 351 of the second valve hole 37.

[0198] In Figs. 29(b) and 29(c), since the second valve hole 37 is closed, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone). Also, since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. That is, in the state shown in Figs. 29(b) and 29(c), the displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32C also does not allow refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0199] The seventeenth embodiment has the same advantages as the advantages (16-1) and (16-2) of the sixteenth embodiment.

[0200] The configuration in which the flange 458 is inserted into the recess 401 contributes to increase in a flow passage area of the second valve hole 37 (the cross-sectional area obtained by subtracting the cross-sectional area $\pi(D7/2)^2$ of the transmission rod 45 in the second valve hole 37 from the cross-sectional area $\pi(D5/2)^2$ of the second valve hole 37, or $\pi((D5/2)^2 - \pi(D7/2)^2)$. D7 represents the diameter of the transmission rod 45 in the second valve hole 37.

[0201] When assembling the displacement control valve 32C, the transmission rod 45 is inserted from the second valve hole 37 to pass through the second valve hole 37, the second valve body 40B, and the first valve hole 36. If the diameter D5 of the second valve hole 37 is too large, the sealing effectiveness between the second valve body 40B and the seating face 351 is degraded. Therefore, the diameter D5 of the second valve hole 37 is minimized while permitting the flange 458 to pass therethrough. In this case, if the diameter D7 of the transmission rod 45 in the second valve hole 37 is equal to that of the flange 458, the flow passage area of the second valve hole 37 is significantly reduced. This hinders flow of refrigerant out to the suction chamber 131 from the control pressure chamber 121. This hinders a reliable control for varying the flow passage area.

[0202] The configuration, in which the flange 458 is inserted into the recess 401, permits a sufficient flow passage area of the second valve 37 to be obtained, and is thus effective for a reliable control for varying the flow passage area.

[0203] An eighteenth embodiment will now be described with reference to Figs. 30(a), 30(b), and 30(c). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the third embodiment shown in Figs. 5(a) to 6(c) and the sixteenth embodiment shown in Figs. 27 and 28.

[0204] A recess 671 is formed in a first valve body 67B, and an auxiliary rod 72 is inserted into the recess 671. An end face 723 of the auxiliary rod 72 selectively contacts a bottom 672 of the recess 671.

[0205] In the state of Fig. 30(a), the end face 723 of the auxiliary rod 72 is separated from the bottom 672. The first valve body 67B contacts the seating face 691 of the valve seat 69 so that the first valve hole 36 is closed. Since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the shared chamber 38 through the first valve hole 36. Also, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121 through the first valve hole 36, the shared chamber 38, and the passage 58. On the other hand, the cylindrical portion 681 of the second valve body 68 is out of the second valve hole 37 so that the second valve hole 37 is open. Since the second valve hole 37 is open, refrigerant in the control pressure chamber 121 flows out to the suction chamber 131 (suction pressure zone) through the passage 58, the shared chamber 38, the second valve hole 37, the chamber 46, and the passage 57. That is, in the state shown in Fig. 30(a), a displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121, while permitting refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0206] In the state of Fig. 30(b), the end face 723 of the auxiliary rod 72 is separated from the bottom 672. The first valve body 67B is in a position where it contacts the seating face 691 of the valve seat 69. That is, the first valve hole 36 is closed by the first valve body 67B. The cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37), and the second valve hole 37 is closed by the second valve body 68.

[0207] In the state of Fig. 30(c), the end face 723 of the auxiliary rod 72 contacts the bottom 672. The first valve body 67B contacts the seating face 691 of the valve seat 69 so that the first valve hole 36 is closed. The cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37), and the second valve hole 37 is closed by the second valve body 68.

[0208] In either of the states shown in Figs. 30(b) and 30(c), the first valve body 67B is in a position where it closes the first valve hole 36, and the second valve body 68 is in a position where it closes the second valve hole 37. As the electromagnetic force of the solenoid 41 is reduced from the state of Fig. 30(b) (a state in which the coupling face 722 of the auxiliary rod 72 is in a position W1), the coupling face 722 is moved from the position W1 toward the first valve hole 36, and the end face 723 approaches the bottom 672. As the electromagnetic force of the solenoid 41 is increased from the state of Fig. 30(c) (a state in which the coupling face 722 of the auxiliary rod 72 is in a position W2), the coupling face 722 is moved from the position W2 toward the position W1, and the end face 723 is separated from the bottom 672. If the coupling face 722 of the auxiliary rod 72 is in a displacement range [W1, W2] from the position W1 to the position W2, the cylindrical portion 681 of the second valve body 68 is in the second valve hole 37 (the boundary 683 is in the second valve hole 37), and the first valve body 67B is in the position where it contacts the seating face 691 of the valve seat 69 (a position where the first valve body 67B closes the first valve hole 36).

[0209] The displacement range [W1, W2] is a predetermined range of a double closing state of the transmission rod 45 and the auxiliary rod 72, in which the first valve body 67B closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. When the transmission rod 45 and the auxiliary rod 72, which are reciprocating bodies, are in the predetermined displacement range [W1, W2], the double closing state occurs, in which the first valve body 67B closes the first valve hole 36, and the second valve body 68 closes the second valve hole 37. This state is obtained because the sum of a distance H21 between the end face 723 and the boundary 683 and a depth H22 of the recess 671 ($H21 + H22 = H2$) is greater than the distance K2 between the open end 371 and the seating face 691.

[0210] In Figs. 30(b) and 30(c), since the second valve hole 37 is closed, refrigerant in the control pressure chamber 121 does not flow out to the suction chamber 131 (suction pressure zone). Also, since the first valve hole 36 is closed, refrigerant in the discharge pressure introducing chamber 103 does not flow into the control pressure chamber 121. That is, in the state shown in Figs. 30(b) and 30(c), the displacement control valve 32C does not allow refrigerant in the circuit section 28C (discharge pressure zone) to flow into the control pressure chamber 121. The displacement control valve 32C also does not allow refrigerant in the control pressure chamber 121 to flow out to the suction chamber 131.

[0211] The eighteenth embodiment has the same advantages as the advantages (16-1) and (16-2) of the sixteenth embodiment.

[0212] A nineteenth embodiment will now be described with reference to Figs. 31(a), 31(b), 31(c), and 32. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment shown in Figs. 1 to 3(c) and the sixteenth embodiment shown in Figs. 27 and 28.

[0213] A first valve body 39 and a second valve body 68B are formed on a transmission rod 45. The second valve body 68B includes a cylindrical portion 681 and a tapered portion 682. The diameter of the tapered portion 682 is reduced in a direction from the first valve hole 36 to the second valve hole 37. The cylindrical portion 681 of the second valve body 68B can enter the second valve hole 37 (the boundary 683 is in the second valve hole 37), thereby closing the second valve hole 37.

[0214] A diameter D4 of the cylindrical portion 681 of the second valve body 68B is greater than a diameter D3 of the cylindrical portion 391 of the first valve body 39. That is, the diameter of the second valve hole 37 is greater than the diameter of the first valve hole 36. Since the diameter of the first valve hole 36 is substantially equal to the diameter D3 of the cylindrical portion 391 of the first valve body 39, the diameter of the first valve hole 36 is assumed to be the diameter D3. Likewise, since the diameter of the second valve hole 37 is substantially equal to the diameter D4 of the cylindrical portion 681 of the second valve body 68B, the diameter of the second valve hole 37 is assumed to be the diameter D4.

[0215] The second valve hole 37 is connected to the suction chamber 131 through a through hole 105 and a communication passage 106 communicating with the through hole 105. The transmission rod 45, which is a reciprocating body, extends through the through hole 105. The shared chamber 38 and the chamber 46 communicate with each other through a passage 107.

[0216] The chamber 46 communicates with a space 104 between the movable iron core 44 and the fixed iron core 42 through a passage 421. The chamber 46 communicates with a back pressure space 98A at the back of the movable iron core 44 through the passages 421 and 442. The pressure in the space 104 and the back pressure space 98A is similar to the pressure in the shared chamber 38 (corresponding to the control pressure). The shared chamber 38 is a first control pressure introducing zone that is defined between the first valve hole 36 and the second valve hole 37. The chamber 46, the space 104, and the back pressure space 98A is a second control pressure introducing zone that is defined to connect the shared chamber 38 (first control pressure introducing zone) with the second valve hole 37.

[0217] The transmission rod 45 extends through the through hole 105 such that the chamber 46, which is part of the second control pressure introducing zone, is shut off from the communication passage 106 when the second valve hole 37 is closed.

[0218] The transmission rod 45 receives a load F5 directed in a direction from the first valve hole 36 to the second valve hole 37 due to the pressure in the first control pressure zone (shared chamber 38). The load F5 is obtained by multiplying the pressure in the first control pressure zone by the difference between cross-sectional area of the first valve hole 36 and the cross-sectional area of the second valve hole 37. The transmission rod 45 also receives a load F6 in a direction from the second valve hole 37 to the first valve hole 36 due to the pressure in the second control pressure introducing zone. The load F6 is obtained by multiplying the cross-sectional area of the second hole 37 by the pressure in the second control pressure introducing zone. That is, the load F5, which is applied to the transmission rod 45 in a direction from the first valve hole 36 to the second valve hole 37, and the load F6, which is applied to the transmission rod 45 in a direction from the second valve hole 37 to the first valve hole 36, oppose each other with the transmission rod 45 in between. Therefore, the load F5, which is applied to the transmission rod 45 in a direction from the first valve hole 36 to the second valve hole 37, is cancelled. A load that is resulted from the pressures in the first and second control pressure introducing zones and actually influences the transmission rod 45 is a load (F6 - F5) that is applied to the transmission rod 45 in a direction from the second valve hole 37 to the first valve hole 36.

[0219] Pressure loads acting on the transmission rod 45 will now be described with reference to Fig. 32.

[0220] S1 in Fig. 32 represents a pressure receiving area of the bellows 50 and the movable body 52 with respect to the displacement direction of the transmission rod 45. Specifically, S1 represents the area of the bellows 50 and the movable body 52 that receives the pressure in the pressure sensing chamber 48. S2 represents the cross-sectional area of the first valve hole 36. The cross-sectional area S2 is expressed by a formula $\pi(D3/2)^2$. S3 represents the a cross-sectional area of the second valve hole 37. The cross-sectional area S3 is expressed by a formula $\pi(D4/2)^2$. S4 represents the cross-sectional area of the through hole 105. In this embodiment, the diameter D5 of the through hole 105 and the diameter D4 of the second valve hole 37 are equal to each other. The cross-sectional area S4 of the through hole 105 is expressed by formulae having the same value, or $\pi(D5/2)^2 = \pi(D4/2)^2 = S3$.

[0221] When the pressure in the pressure sensing chamber 48, the pressure in the pressure sensing chamber, the control pressure, and the suction pressure are represented by PdH, PdL, Pc, and Ps, the pressure load acting on the transmission rod 45 is expressed by the formula (1).

$$T = S1 \times (PdH - PdL) + S2 \times (PdL - Pc) + S3 \times (Pc - Ps) - S4 \times (Pc - Ps) \quad (1)$$

[0222] The formula (1) indicates that the influence of the control pressure Pc manifests itself as the difference (PdL - Pc) between the discharge pressure Pd and the control pressure Pc, and the difference (Pc - Ps) between the control pressure Pc and the suction pressure Ps. The above mentioned load (F6 - F5) is expressed by a formula ($S3 \times Pc - S4 \times Pc$).

[0223] The transmission rod 45 receives a load in a direction from the first valve hole 36 to the second valve hole 37 due to the pressure in the pressure sensing chamber 48 (discharge pressure PdH). The load is obtained by multiplying the cross-sectional area of the first valve hole 36 and the discharge pressure PdH. This load acts against the load (F6 - F5) and cancel the load (F6 - F5) to a considerable degree by appropriately setting the diameter of the first valve hole 36.

[0224] In a case where the passage 107 is not formed (that is if the chamber 46 is not connected to the shared chamber 38), if the pressure in the chamber 46 is equal to the atmospheric pressure, it is difficult to cancel the load F5, which acts on the transmission rod 45 and is in a direction from the first valve hole 36 to the second valve hole 37. That is, the opening degree control of the first and second valve holes 36, 37 is affected by the pressure in the shared chamber 38 (corresponding to the control pressure). As a result, the opening degrees of the first and second valve holes 36, 37 are not reliably controlled. In the illustrated example, the transmission rod 45 can pass a desired position when moving in a direction from the first valve hole 36 to the second valve hole 37.

[0225] The present embodiment, in which the load F5, which acts on the transmission rod 45 in a direction from the first valve hole 36 to the second valve hole 37 is cancelled, avoids problems in the opening degree control of the first and second valve holes 36, 37 ascribable to the pressure in the shared chamber 38 (corresponding to the control pressure).

[0226] In this embodiment, since S3 = S4, the formula (1) can be changed to the formula (2).

$$T = S1 \times (PdH - PdL) + S2 \times (PdL - Pc) \quad (2)$$

[0227] The formula (2) indicates that the influence of the control pressure Pc manifests itself as the difference (PdL - Pc) between the discharge pressure Pd and the control pressure Pc. That is, in the configuration where the cross-sectional area S4 of the through hole 105 is equal to the cross-sectional area S3 of the second valve hole 37, the difference between the control pressure Pc and the suction pressure Ps does not manifest itself as a pressure load acting on the transmission rod 45 (reciprocating body). Since the control pressure Pc is approximate to the suction pressure Ps, a change to (fluctuation of) the control pressure Pc made by the displacement control valve 32C affects the difference (Pc - Ps). On the contrary, since the pressure PdL is greatly different from the control pressure Pc, fluctuations of the control pressure Pc do not fluctuate the difference (PdL - Pc) by a great degree. Therefore, the configuration in which the difference (Pc - Ps) is cancelled, is favorable for reliably controlling the opening degrees of the first valve hole 36 and the second valve hole 37.

[0228] When the cylindrical portion 391 of the first valve body 39 is not in the first valve hole 36, the flow passage area of the first valve hole 36 is equal to or less than the cross-sectional area [$\pi((D4/2)^2 - \pi(D8/2)^2)$], which is obtained by subtracting the cross-sectional area $\pi(D8/2)^2$ of a small diameter portion 45d1 of the transmission rod 45 from the cross-sectional area $\pi(D3/2)^2$ of the first valve hole 36. D8 is the diameter of the small diameter portion 45d1. Even If the flow passage area of the first valve hole 36 is small (that is, even if the diameter D3 of the first valve hole 36 is small), a flow of refrigerant from the pressure sensing chamber 49 to the control pressure chamber 121 is not hindered.

[0229] When the cylindrical portion 681 of the second valve body 68 is not in the second valve hole 37, the flow passage area of the second valve hole 37 is equal to or less than the cross-sectional area [$\pi((D4/2)^2 - \pi(D9/2)^2)$], which is obtained by subtracting the cross-sectional area $\pi(D9/2)^2$ of a middle diameter portion 45d2 of the transmission rod 45 from the cross-sectional area $\pi(D4/2)^2$ of the second valve hole 37. D9 is the diameter of the middle diameter portion 45d2. If the flow passage area of the second valve hole 37 (that is, the diameter D4 of the second valve hole 37) is as small as the flow passage area of the first valve hole 36 (that is, the diameter D3 of the first valve hole 36), flow of refrigerant from the control pressure chamber 121 to the suction chamber 131 is hindered. This hinders a reliable control for varying the flow passage area.

[0230] The configuration, in which the diameter of the second valve hole 37 is greater than the diameter of the first valve hole 36, permits a sufficient flow passage area of the second valve 37, and is thus effective for a reliable control for varying the flow passage area.

[0231] A twentieth embodiment will now be described with reference to Figs. 33(a) and 33(b). Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the nineteenth embodiment shown in Figs. 31 to 32.

[0232] As shown in Fig. 33(a), the twentieth embodiment is the same as the nineteenth embodiment except that a diameter D10 of the second valve hole 37 is different from a diameter D11 of the through hole 105. S2 shown in Fig. 33 (b) represents the cross-sectional area of the first valve hole 36. The cross-sectional area S2 is expressed by a formula $\pi(D3/2)^2$. S5 represents the a cross-sectional area of the second valve hole 37. The cross-sectional area S5 is expressed by a formula $\pi(D10/2)^2$. S6 represents the cross-sectional area of the through hole 105. The cross-sectional area S4 of the through hole 105 is expressed by a formula $\pi(D11/2)^2$. In this embodiment, the equation S6 = S5 - S2 is satisfied.

[0233] In this embodiment, since the equation S6 = S5 - S2 is satisfied, the formula (1) can be changed to the formula (3).

$$T = S1 \times (PdH - PdL) + S2 \times (PdL - Ps) \quad (3)$$

[0234] The formula (3) indicates that the influence of the control pressure Pc does not manifest itself as a pressure load acting on the transmission rod 45 (reciprocating body). That is, in the configuration where the difference between the cross-sectional area S5 of the second valve hole 37 and the cross-sectional area S6 of the through hole 105 is equal to the cross-sectional area S2 of the first valve hole 36 does not permit the control pressure Pc to manifest itself as a pressure load acting on the transmission rod 45. The displacement control valve 32C is configured to control the control pressure Pc, thereby controlling the displacement of the variable displacement compressor 10. Therefore, the configuration in which the control pressure Pc is cancelled so that the control pressure Pc does not affect a pressure load T is more favorable for reliably controlling the opening degrees of the first valve hole 36 and the second valve hole 37 than the nineteenth embodiment.

[0235] The invention may be embodied in the following forms.

(1) In the first embodiment, the tapered portion 392 of the first valve body 39 may be omitted, and a tapered portion 363 may be formed in the first valve hole 36 as shown in Fig. 23. That is, the opening of the first valve hole 36, which corresponds to the first valve body 39 functioning as a fixed valve body, may widen toward the first valve body 39. The tapered portion 363, which is a groove in the first valve hole, 36 has a similar function as the tapered portion 392 in the first embodiment. In this case, an upper end 365 of the tapered portion 363 of the first valve hole 36 functions as a second initial contact portion, which is a portion of the circumferential surface of the first valve hole 36 that initially contacts the boundary 393 when the first valve hole 36 is switched from the open state to the closed state. That is, to ensure that the predetermined displacement range [W1, W2] be created, the distance H1 between the displacement transmission portion (the step 451) and the first initial contact portion (the boundary 393 of the first valve body 39) is different from the distance K1 between the second initial contact portion (the upper end 365 of the tapered portion 363) and the seating face 351.

(2) In the third embodiment, the tapered portion 682 of the second valve body 68 may be omitted, and a tapered portion 373 may be formed in the second valve hole 37 as shown in Fig. 24. The tapered portion 373 in the second valve hole 37 has a similar function as the tapered portion 682 in the third embodiment. In this case, a lower end 375 of the tapered portion 373 of the second valve hole 37 functions as a second initial contact portion, which is a portion of the circumferential surface of the second valve hole 37 that initially contacts the boundary 683 when the second valve hole 37 is switched from the open state to the closed state.

(3) In the sixth embodiment, the tapered portion 395 of the first valve body 39A may be omitted, and a tapered portion 364 may be formed in the first valve hole 36A as shown in Fig. 25. The tapered portion 364 in the first valve hole 36A has a similar function as the tapered portion 395 in the sixth embodiment.

(4) In the eighth embodiment, the tapered portion 685 of the second valve body 68A may be omitted, and a tapered portion 374 may be formed in the second valve hole 37A as shown in Fig. 26. The tapered portion 374 in the second valve hole 37A has a similar function as the tapered portion 685 in the eighth embodiment.

(5) A displacement control valve of a variable electromagnetic force type may be used, which has a pressure sensing member that senses a pressure difference between two positions in a suction pressure zone.

(6) The present invention may be applied to a clutchless type variable displacement compressor. In such a variable displacement compressor, circulation of refrigerant is stopped in an external refrigerant circuit when the inclination angle of a swash plate is the minimum.

(7) In the seventeenth and eighteenth embodiments, the first valve body 67B and the second valve body 40B may be used as first and second valve bodies.

(8) In the nineteenth and twentieth embodiments, the first valve body 67B may be used as a first valve body.

(9) In the nineteenth and twentieth embodiments, the second valve body 40B may be used as a second valve body.

[0236] The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A displacement control valve (32) for a variable displacement compressor (10), the compressor (10) having:

a discharge pressure zone (132) exposed to the pressure of refrigerant that has been compressed by the compressor (10); a suction pressure zone (131) exposed to the pressure of refrigerant that is drawn into the compressor (10); a control pressure chamber (121); a supply passage (26) that connects the discharge pressure zone (132) to the control pressure chamber (121); and a discharge passage (27) that connects the suction pressure zone (131) to the control pressure chamber (121), wherein the control valve (32) adjusts the pressure of the control pressure chamber (121) by supplying refrigerant in the discharge pressure zone (132) to the control pressure chamber (121) through the supply passage (26) and discharging refrigerant in the control pressure chamber (121) to the suction pressure zone (131) through the discharge passage (27), thereby controlling the displacement of the compressor, wherein the control valve (32) comprises:

a first valve hole (36; 36A; 92) forming a part of the supply passage (26);
a first valve body (39; 39A; 67; 67A; 90) that selectively opens and closes the first valve hole (36; 36A; 92);
a second valve hole (37; 37A; 94) forming a part of the discharge passage;
a second valve body (40; 40A; 68; 68A; 68B; 89) that selectively opens and closes the second valve hole; (37; 37A; 94); and
a reciprocating body (45) that is capable of being displaced and reciprocated, wherein displacement of the reciprocating body (45) is transmitted to each of the first (39; 39A; 68) and second (40; 67) valve bodies so that each valve body opens or closes the corresponding valve hole;
the control valve being **characterized in that:**

when the reciprocating body (45) is within a predetermined displacement range, a double closing state occurs in which the first valve body (39; 39A; 67; 67A; 90) closes the first valve hole (36; 36A; 92) and the second valve body (40; 40A; 68; 68A; 68B; 89) closes the second valve hole (37; 37A; 94),

wherein, when the reciprocating body (45) is out of the displacement range, a single closing state occurs in which only one of the first valve body (39; 39A; 67; 67A; 90) and the second valve body (40; 40A; 68; 68A; 68B; 89) closes the corresponding one of the valve holes.

2. The control valve according to claim 1,
characterized by:

a distance changing mechanism that changes the distance between the first valve body (39; 39A; 67; 67A; 90) and the second valve body (40; 40A; 68; 68A; 89) according to the position of the reciprocating body (45) when the reciprocating body (45) is displaced, thereby causing the double closing state or the singly closing state to occur, and wherein, when at least one of the first and second valve bodies is at a specific position and closes the corresponding valve hole, the distance changing mechanism permits the reciprocating body (45) to be displaced relative to the valve body at the specific position.

3. The control valve according to claim 2,
characterized in that only one of the first and second valve bodies is a fixed valve body (39; 39A; 68; 68A) that is fixed to the reciprocating body (45), and wherein, when the reciprocating body (45) is in the predetermined displacement range, the fixed valve body (39; 39A; 68; 68A) enters the valve hole (36; 37) that corresponds to the fixed valve body (39; 39A; 68; 68A) to close the valve hole (36; 37).

4. The control valve according to claim 3,
characterized in that the fixed valve body (39; 39A; 68; 68A) includes a tapered portion (392; 395; 682; 685) that enters and exits the corresponding valve hole (36; 37).

5. The control valve according to claim 3,
characterized in that an opening (363; 364; 373; 374) of the valve hole (36; 37) that corresponds to the fixed valve body (39; 39A; 68; 68A) widens toward the fixed valve body (39; 39A; 68; 68A).

6. The control valve according to any one of claims 3 to 5,
characterized in that one of the first and second valve bodies that is not the fixed valve body (39; 39A; 68; 68A) is a sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) that is slidably fitted to the reciprocating body (45), wherein the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) is capable of being moved between a closing position for closing the corresponding valve hole (36; 37) and an opening position for opening the valve hole (36; 37), wherein the reciprocating body (45) includes a displacement transmission portion (451; 721; 456; 457; 871) that contacts the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) to transmit displacement of the reciprocating

body (45) to the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89), thereby moving the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) from the closing position to the opening position, and
wherein the distance changing mechanism includes the displacement transmission portion (451; 721; 456; 457; 871) and an urging member (47; 71; 82; 84; 86) for urging the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) toward the displacement transmission portion (451; 721; 456; 457; 871).

7. The control valve according to claim 6,
characterized by a seating face (351; 691; 771; 772; 851; 911; 931) in which a valve hole (37; 36) that corresponds to the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) opens,
wherein the sliding valve body (40; 40A; 67; 67A; 40B; 67B; 90; 89) has a valve closing face (403; 673; 893; 903) that contacts the seating face (351; 691; 771; 772; 851; 911; 931) to close the corresponding valve hole (37; 36), the displacement transmission portion (451; 721; 456; 457; 871) being capable of contacting the valve closing face (403; 673; 893; 903),
wherein the fixed valve body (39; 39A; 68; 68A) has a first initial contact portion (393; 396; 683; 686), and the circumferential surface of the valve hole (36; 37) that corresponds to the fixed valve body (39; 39A; 68; 68A) has a second initial contact portion (361; 371), wherein, when the fixed valve body switches the corresponding valve hole (36; 37) from an open state to a closed state, the first initial contact portion (393; 396; 683; 686) initially contacts the circumferential surface of the corresponding valve hole (36; 37), and the second initial contact portion (361; 371) initially contacts the first initial contact portion (393; 396; 683, 686), and
wherein, to ensure that a predetermined displacement range be created, the distance (H1; H2) between the displacement transmission portion (451; 721; 456; 457; 871) and the first initial contact portion (393; 396; 683; 686) is different from the distance (K1; K2) between the second initial contact portion (361; 371) and the seating face (351; 691; 771; 772; 851; 911; 931).

8. The control valve according to claim 6,
characterized by a seating face in which a valve hole (37) that corresponds to the sliding valve body (40B) opens, wherein the sliding valve body (40B) has a valve closing face (403) that contacts the corresponding seating face (351) to close the corresponding valve hole (37), and a displacement receiving face (402) that is capable of contacting the displacement transmission portion (459), the valve closing face (403) and the displacement receiving face (402) being separated from each other with respect to a direction of displacement of the reciprocating body (45), wherein the fixed valve body (39) has a first initial contact portion (393), and the circumferential surface of the valve hole (36) that corresponds to the fixed valve body (39) has a second initial contact portion (361),
wherein, when the fixed valve body (39) switches the corresponding valve hole (36) from an open state to a closed state, the first initial contact portion (393) initially contacts the circumferential surface of the corresponding valve hole (36), and the second initial contact portion (361) initially contacts the first initial contact portion (393), and
wherein, to ensure that a predetermined displacement range be created, the sum of the distance (H11) between the displacement transmission portion (459) and the first initial contact portion (393) and the distance (H12) between the valve closing face (403) and the displacement receiving face (402) is different from the distance (K1) between the second initial contact portion (361) and the seating face (351).

9. The control valve according to claim 8,
characterized in that the sliding valve body has a recess (401), a hole trough which the reciprocating body (45) extends being formed in a bottom of the recess (401), and
wherein an open end of the recess (401) forms the valve closing face (403), and the bottom of the recess forms the displacement receiving face (459).

10. The control valve according to claim 2,
characterized in that the first valve body (67) and the second valve body (40) are slidably fitted to the reciprocating body (45), and
wherein the reciprocating body (45) includes:

a first displacement transmission portion (871) that contacts the first valve body (67) to transmit displacement of the reciprocating body (45) to the first valve body (67), thereby moving the first valve body (67) from the closing portion to the opening position, and
a second displacement transmission portion (451) that contacts the second valve body (40) to transmit displacement of the reciprocating body (45) to the second valve body (40), thereby moving the second valve body (40) from the closing position to the opening position,
wherein the distance changing mechanism includes the first displacement transmission portion (871), the second

displacement transmission portion (451), a first urging member (99) for urging the first valve body (67) toward the first displacement transmission portion (871), and a second urging member (86) for urging the second valve body (40) toward the second displacement transmission portion (451).

11. The control valve according to claim 10,
characterized by a seating face (851) in which the first valve hole (36) opens and a seating face (351) in which the second valve hole (37) opens,
wherein, to ensure that a predetermined displacement range be created, the distance (K7) between the seating faces (351, 851) is different from the distance (H7) between the first displacement transmission portion (871) and the second displacement transmission portion (451).

12. The control valve according to claim 1,
characterized in that the first valve body (39A) and the second valve body (68A) are fixed to the reciprocating body (45A), and
wherein, when the reciprocating body (45A) is in the predetermined displacement range, the first valve body enters (39A) the first valve hole (36A) to close the first valve hole (36A), and the second valve body (68A) enters the second valve hole (37A) to close the second valve hole (37A).

13. The control valve according to claim 12,
characterized in that the first and second valve bodies (39A, 68A) each have a first initial contact portion (396, 686), and the circumferential surface of each valve hole (36A, 37A) has a second initial contact portion (362, 372),
wherein, when one of the first and second valve bodies (39A, 68A) switches the corresponding valve hole (36A, 37A) from an open state to a closed state, the first initial contact portion (396, 686) of the one of the first and second valve bodies (39A, 68A) initially contacts the circumferential surface of the valve holes (36A, 37A), and the second initial contact portion (362, 372) of the valve hole (36, 37) initially contacts the first initial contact portion (396, 686), and
wherein, to ensure that a predetermined displacement range be created, the distance (H6) between the first initial contact portions (396, 686) is different from the distance (K6) between the second initial contact portions (362, 372).

14. The control valve according to claim 12 or 13,
characterized in that the first and second valve bodies (39A, 68A) each have a tapered portion (395, 685), and where each tapered portion (395, 685) enters and exits the corresponding valve hole (36A, 37A).

15. The control valve according to claim 14,
characterized in that, to ensure that a predetermined displacement range be created, the distance between proximal ends of the tapered portions (395, 685) is different from the distance between open ends of the first and second valve holes (36A, 37A).

16. The control valve according to any one of claims 1 to 15,
characterized in that a shared chamber (38) is defined between the first valve hole (36) and the second valve hole (37), the first valve hole (36) and the second valve hole (37) opening the shared chamber (38),
wherein the shared chamber (38) communicates with the control pressure chamber (30), the first valve hole (36) communicates with the discharge pressure zone (132), and the second valve hole (37) communicates with the suction pressure zone (131), and
wherein, when the first valve body (39) opens the first valve hole (36), the shared chamber (38) communicates with the discharge pressure zone (132) through the first valve hole (36), and, when the second valve body (40) opens the second valve hole (37), the shared chamber (38) communicates with the suction pressure zone (131) through the second valve hole (37).

17. The control valve according to any one of claims 1 to 15,
characterized in that the first valve hole (36) is connected to the second valve hole (37), the reciprocating body (45) extending through the first valve hole (36) and the second valve hole (37),
wherein the reciprocating body (45) has a separation portion (62) that separates the second valve hole (37) from the first valve hole (36),
wherein the control pressure chamber (121) is connected to the discharge pressure zone (132) through the first valve hole (36), and is connected to the suction pressure zone (131) through the second valve hole (37), and
wherein, when the first valve body (39) opens the first valve hole (36) the control pressure chamber (121) communicates with the discharge pressure zone (132) through the first valve hole (36), and, when the second valve body (40) opens the second valve hole (37), the control pressure chamber (121) communicates with the suction pressure

zone (131) through the second valve hole (37).

18. The control valve according to claim 16 or 17,
characterized by:

a first discharge pressure chamber (98) and a second discharge pressure chamber (48), which are arranged with the first (92) and second (94) valve holes in between,
wherein the reciprocating body (45) has a first end that extends through the first valve hole (92) and receives the pressure of the first discharge pressure chamber (98), and a second end that extends through the second valve hole (94) and receives the pressure of the second discharge pressure chamber (48), and
wherein the pressure of the first discharge pressure chamber (98) acts against the pressure of the second discharge pressure chamber (48) through the reciprocating body (45).

19. The control valve according to claim 16 or 17,
characterized by:

a discharge pressure introducing chamber (103) that is exposed to the pressure of the discharge pressure zone (132); and
a suction pressure introducing chamber (46, 104, 98A) that is exposed to the pressure of the suction pressure zone (131),
wherein the first valve hole (36) and the second valve hole (37) are arranged between the discharge pressure introducing chamber (103) and the suction pressure introducing chamber (46, 104, 98A),
wherein the reciprocating body (45) has a first end that extends through the first valve hole (36) and receives the pressure of the discharge pressure introducing chamber (103), and a second end that extends through the second valve hole (37) and receives the pressure of the suction pressure introducing chamber (46, 104, 98A), and
wherein the pressure of the suction pressure introducing chamber (46, 104, 98A) acts against the pressure of the discharge pressure introducing chamber (103) through the reciprocating body (45).

20. The control valve according to claim 19,
characterized by:

a solenoid (41) for urging the reciprocating body (45) from the second valve hole (37) toward the first valve hole (36); and
a first urging spring (102) and a second urging spring (56) that urge the reciprocating body (45) from the first valve hole (36) toward the second valve hole (37).

21. The control valve according to any one of claims 1 to 20, **characterized by:**

a control pressure introducing member (38) that is exposed to the pressure of the control pressure chamber (121),
wherein the control pressure introducing chamber (38) is defined between the first valve hole (36) and the second valve hole (37), the control pressure introducing chamber (38) connecting the first valve hole (36) and the second valve hole (37) to each other,
wherein the diameter of the first valve hole (36) is the same as the diameter of the second valve hole (37).

22. The control valve according to any one of claims 1 to 20, **characterized by:**

a first control pressure introducing zone (38) and a second control pressure introducing zone (98A) that are exposed to the pressure of the control pressure chamber (121),
wherein the first control pressure introducing zone (38) is defined between the first valve hole (36) and the second valve hole (37),
wherein the first valve hole (36) opens the first control pressure introducing zone (38),
wherein the second valve hole (37) opens the first control pressure introducing zone (38) and the second control pressure introducing zone (98A),
wherein the first control pressure introducing zone (38) is connected to the second control pressure introducing zone (98A),
wherein the pressure of the first control pressure introducing zone (38) acts against the pressure of the second control pressure introducing zone (98A) trough the reciprocating body (45), and
wherein the diameter of the first valve hole (36) is different from the diameter of the second valve hole (37).

23. The control valve according to claim 22, **characterized in that** the diameter of the second valve hole (37) is greater than the diameter of the first valve hole (36).

24. The control valve according to claim 22 or 23,
characterized in that the second valve hole (37) opens to the suction pressure zone (131) through a through hole (105) that permits the reciprocating body (45) to extend therethrough and a communication passage (106) that communicates with the through hole (105), and
wherein, closing the second valve hole (37), the reciprocating body (45) disconnects the second control pressure introducing zone (98A) from the communication passage (106).

25. The control valve according to claim 24,
characterized in that the cross-sectional area of the through hole (105) is the same as the cross-sectional area of the second valve hole (37).

26. The control valve according to claim 24,
characterized in that cross-sectional area of the second valve hole (37) is greater than the cross-sectional area of the first valve hole (36), and
wherein the cross-sectional area of the trough hole (105) is the same as the value obtained by subtracting the cross-sectional area of the first valve hole (36) from the cross-sectional area of the second valve hole (37).

27. The control valve according to any one of claims 1 to 17, **characterized by** a solenoid (41) for actuating the reciprocating body.

28. The control valve according to any one claims 1 to 18 and 27, **characterized by:**

a pressure sensing member (54) that detects a pressure difference between two points in the discharge pressure zone (132) or a pressure difference between two points in the suction pressure zone (131), wherein the pressure sensing member (54) displaces the reciprocating body (45) by using the pressure difference.

Patentansprüche

1. Verdrängungssteuerventil (32) für einen Kompressor mit variabler Verdrängung (10), wobei der Kompressor (10) aufweist:

eine Auslassdruckzone (132), die dem Druck eines Kühlmittels ausgesetzt ist, das durch den Kompressor (10) verdichtet wurde; eine Saugdruckzone (131), die dem Druck des Kühlmittels ausgesetzt ist, das in den Kompressor (10) eingesaugt wird; eine Steuerdruckkammer (121); einen Zuführdurchgang (26), der die Auslassdruckzone (132) mit der Steuerdruckkammer (121) verbindet; und einem Auslassdurchgang (27), der die Saugdruckzone (131) mit der Steuerdruckkammer (121) verbindet, wobei das Steuerventil (32) den Druck der Steuerdruckkammer (121) einstellt, indem es ein Kühlmittel in der Auslassdruckzone (132) durch den Zuführdurchgang (26) der Steuerdruckkammer (121) zuführt und ein Kühlmittel in der Steuerdruckkammer (121) durch den Auslassdurchgang (27) zu der Saugdruckzone (131) abgibt, wodurch es die Verdrängung des Kompressors steuert, wobei das Steuerventil (32) aufweist:

eine erste Ventilöffnung (36; 36A; 92), die einen Teil des Zuführdurchgangs (26) bildet;
einen ersten Ventilkörper (39; 39A; 67; 67A; 90), der die erste Ventilöffnung (36; 36A; 92) wahlweise öffnet und schließt;
eine zweite Ventilöffnung (37; 37A; 94), die einen Teil des Auslassdurchgangs bildet;
einen zweiten Ventilkörper (40; 40A; 68; 68A; 68B; 89), der die zweite Ventilöffnung (37; 37A; 94) wahlweise öffnet und schließt; und
einen hin- und herbeweglichen Körper (45), der dazu imstande ist, versetzt und hin- und herbewegt zu werden, wobei ein Versatz des hin- und herbeweglichen Körpers (45) zu jedem von dem ersten (39; 39A; 68) und dem zweiten (40; 67) Ventilkörper übertragen wird, so dass jeder Ventilkörper die korrespondierende Ventilöffnung öffnet oder schließt;
wobei das Steuerventil **dadurch gekennzeichnet ist, dass**
dann, wenn sich der hin- und herbewegliche Körper (45) in einem vorbestimmten Versetzungsbereich befindet, ein Zweifach-Schließzustand auftritt, bei dem der erste Ventilkörper (39; 39A; 67; 67A; 90) die

erste Ventilöffnung (36; 36A; 92) schließt und der zweite Ventilkörper (40; 40A; 68; 68A; 68B; 89) die zweite Ventilöffnung (37; 37A; 94) schließt,
wobei dann, wenn sich der hin- und herbewegliche Körper (45) außerhalb des Versetzungsbereiches befindet, ein Einfach-Schließzustand auftritt, bei dem nur einer von dem ersten Ventilkörper (39; 39A; 67; 67A; 90) und dem zweiten Ventilkörper (40; 40A; 68; 68A; 68B; 89) die korrespondierende der Ventilöffnungen schließt.

2. Steuerventil gemäß Anspruch 1, **gekennzeichnet durch**
einen Abstandsänderungsmechanismus, der den Abstand zwischen dem ersten Ventilkörper (39; 39A; 67; 67A; 90) und dem zweiten Ventilkörper (40; 40A; 68; 68A; 89) entsprechend der Position des hin- und herbeweglichen Körpers (45) ändert, wenn der hin- und herbewegliche Körper (45) versetzt wird, wodurch er bewirkt, dass der Zweifach-Schließzustand oder der Einfach-Schließzustand auftritt, und wobei dann, wenn sich zumindest einer von dem ersten und dem zweiten Ventilkörper bei einer bestimmten Position befindet und die korrespondierende Ventilöffnung schließt, der Abstandsänderungsmechanismus es dem hin- und herbeweglichen Körper (45) gestattet, bei der bestimmten Position relativ zu dem Ventilkörper versetzt zu werden.

3. Steuerventil gemäß Anspruch 2, **dadurch gekennzeichnet, dass** nur einer von dem ersten und dem zweiten Ventilkörper ein befestigter Ventilkörper (39; 39A; 68; 68A) ist, der an dem hin- und herbeweglichen Körper (45) befestigt ist, und wobei dann, wenn sich der hin- und herbewegliche Körper (45) in dem vorbestimmten Versetzungsbereich befindet, der befestigte Ventilkörper (39; 39A; 68; 68A) in die Ventilöffnung (36; 37) eintritt, die zu dem befestigten Ventilkörper (39; 39A; 68; 68A) korrespondiert, um die Ventilöffnung (36; 37) zu schließen.

4. Steuerventil gemäß Anspruch 3,
dadurch gekennzeichnet, dass der befestigte Ventilkörper (39; 39A; 68; 68A) einen abgeschrägten Abschnitt (392; 395; 682; 685) aufweist, der in die korrespondierende Ventilöffnung (36; 37) eintritt und aus dieser austritt.

5. Steuerventil gemäß Anspruch 3,
dadurch gekennzeichnet, dass sich eine Öffnung (363; 364; 373; 374) der Ventilöffnung (36; 37), die zu dem befestigten Ventilkörper (39; 39A; 68; 68A) korrespondiert, zu dem befestigten Ventilkörper (39; 39A; 68; 68A) hin aufweitet.

6. Steuerventil gemäß einem der Ansprüche 3 bis 5,
dadurch gekennzeichnet, dass einer von dem ersten und dem zweiten Ventilkörper, der nicht der befestigte Ventilkörper (39; 39A; 68; 68A) ist, ein gleitbarer Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) ist, der gleitbar an dem hin- und herbeweglichen Körper (45) befestigt ist,
wobei der gleitbare Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) dazu imstande ist, zwischen einer Schließposition zum Schließen der korrespondierenden Ventilöffnung (36; 37) und einer Öffnungsposition zum Öffnen der Ventilöffnung (36; 37) bewegt zu werden,
wobei der hin- und herbewegliche Körper (45) einen Versetzungsübertragungsabschnitt (451; 721; 456; 457; 871) aufweist, der den gleitbaren Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) berührt, um einen Versatz des hin- und herbeweglichen Körpers (45) zu dem gleitbaren Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) zu übertragen, wodurch der gleitbare Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) von der Schließposition zu der Öffnungsposition bewegt wird, und
wobei der Abstandsänderungsmechanismus den Versetzungsübertragungsabschnitt (451; 721; 456; 457; 871) und ein Drängbauteil (47; 71; 82; 84; 86) zum Drängen des gleitbaren Ventilkörpers (40; 40A; 67; 67A; 40B; 67B; 90; 89) in Richtung Versetzungsübertragungsabschnitt (451; 721; 456; 457; 871) aufweist.

7. Steuerventil gemäß Anspruch 6,
gekennzeichnet durch eine Sitzfläche (351; 691; 771; 772; 851; 911; 931), in die eine Ventilöffnung (37; 36) öffnet, die zu dem gleitbaren Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) korrespondiert,
wobei der gleitbare Ventilkörper (40; 40A; 67; 67A; 40B; 67B; 90; 89) eine Ventilschließfläche (403; 673; 893; 903) aufweist, die die Sitzfläche (351; 691; 771; 772; 851; 911; 931) berührt, um die korrespondierende Ventilöffnung (37; 36) zu schließen, wobei der Versetzungsübertragungsabschnitt (451; 721; 456; 457; 871) dazu imstande ist, die Ventilschließfläche (403; 673; 893; 903) zu berühren,
wobei der befestigte Ventilkörper (39; 39A; 68; 68A) einen ersten Erstkontaktabschnitt (393; 396; 683; 686) aufweist, und die Umfangsfläche der Ventilöffnung (36; 37), die zu dem befestigten Ventilkörper (39; 39A; 68; 68A) korrespondiert, einen zweiten Erstkontaktabschnitt (361; 371) aufweist, wobei dann, wenn der befestigte Ventilkörper die korrespondierende Ventilöffnung (36; 37) von einem Öffnungszustand in einen Schließzustand umschaltet, der

erste Erstkontaktabschnitt (393; 396; 683; 686) die Umfangsfläche der korrespondierenden Ventilöffnung (36; 37) zuerst berührt und der zweite Erstkontaktabschnitt (361; 371) den ersten Erstkontaktabschnitt (393; 396; 683; 686) zuerst berührt, und
wobei, um sicherzustellen, dass ein vorbestimmter Versetzungsbereich erzeugt wird, der Abstand (H1; H2) zwischen dem Versetzungsübertragungsabschnitt (451; 721; 456; 457; 871) und dem ersten Erstkontaktabschnitt (393; 396; 683; 686) von dem Abstand (K1; K2) zwischen dem zweiten Erstkontaktabschnitt (361; 371) und der Sitzfläche (351; 691; 771; 772; 851; 911; 931) unterschiedlich ist.

8. Steuerventil gemäß Anspruch 6,
gekennzeichnet durch eine Sitzfläche, in die eine Ventilöffnung (37) öffnet, die zu dem gleitbaren Ventilkörper (40B) korrespondiert,
wobei der gleitbare Ventilkörper (40B) eine Ventilschließfläche (403) aufweist, die die korrespondierende Sitzfläche (351) berührt, um die korrespondierende Ventilöffnung (37) zu schließen, und eine Versetzungsaufnahmefläche (402) aufweist, die dazu imstande ist, den Versetzungsübertragungsabschnitt (459) zu berühren, wobei die Ventilschließfläche (403) und die Versetzungsaufnahmefläche (402) bezüglich einer Richtung eines Versatzes des hin- und herbeweglichen Körpers (45) voneinander getrennt sind, wobei der befestigte Ventilkörper (39) einen ersten Erstkontaktabschnitt (393) aufweist und die Umfangsfläche der Ventilöffnung (36), die zu dem befestigten Ventilkörper (39) korrespondiert, einen zweiten Erstkontaktabschnitt (361) aufweist,
wobei dann, wenn der befestigte Ventilkörper (39) die korrespondierende Ventilöffnung (36) von einem Öffnungszustand in einen Schließzustand schaltet, der erste Erstkontaktabschnitt (393) die Umfangsfläche der korrespondierenden Ventilöffnung (36) zuerst berührt, und der zweite Erstkontaktabschnitt (361) den ersten Erstkontaktabschnitt (393) zuerst berührt, und
wobei, um sicherzustellen, dass ein vorbestimmter Versetzungsbereich erzeugt wird, die Summe von dem Abstand (H11) zwischen dem Versetzungsübertragungsabschnitt (459) und dem ersten Erstkontaktabschnitt (393) und der Abstand (H12) zwischen der Ventilschließfläche (403) und der Versetzungsaufnahmefläche (402) unterschiedlich zu dem Abstand (K1) zwischen dem zweiten Erstkontaktabschnitt (361) und der Sitzfläche (351) ist.

9. Steuerventil gemäß Anspruch 8,
dadurch gekennzeichnet, dass
der gleitbare Ventilkörper eine Vertiefung (401) aufweist, wobei eine Öffnung, durch die sich der hin- und herbewegliche Körper (45) erstreckt, in einem Unterteil der Vertiefung (401) ausgebildet ist, und
wobei ein Öffnungsende der Vertiefung (401) die Ventilschließfläche (403) ausbildet und der Unterteil der Vertiefung die Versetzungsaufnahmefläche (459) ausbildet.

10. Steuerventil gemäß Anspruch 2,
dadurch gekennzeichnet, dass
der erste Ventilkörper (67) und der zweite Ventilkörper (40) gleitbar an dem hin- und herbeweglichen Körper (45) befestigt sind, und
wobei der hin- und herbewegliche Körper (45) aufweist:

einen ersten Versetzungsübertragungsabschnitt (871), der den ersten Ventilkörper (67) berührt, um einen Versatz des hin- und herbeweglichen Körpers (45) zu dem ersten Ventilkörper (67) zu übertragen, wodurch der erste Ventilkörper (67) von der Schließposition zu der Öffnungsposition bewegt wird, und
einen zweiten Versetzungsübertragungsabschnitt (451), der den zweiten Ventilkörper (40) berührt, um einen Versatz des hin- und herbeweglichen Körpers (45) zu dem zweiten Ventilkörper (40) zu übertragen, wodurch der zweite Ventilkörper (40) von der Schließposition zu der Öffnungsposition bewegt wird,
wobei der Abstandsänderungsmechanismus den ersten Versetzungsübertragungsabschnitt (871), den zweiten Versetzungsübertragungsabschnitt (451), ein erstes Drängbauteil (99) zum Drängen des ersten Ventilkörpers (67) in Richtung erstem Versetzungsübertragungsabschnitt (871) und ein zweites Drängbauteil (86) zum Drängen des zweiten Ventilkörpers (40) in Richtung zweitem Versetzungsübertragungsabschnitt (451) aufweist.

11. Steuerventil gemäß Anspruch 10,
gekennzeichnet durch eine Sitzfläche (851), in die die erste Ventilöffnung (36) öffnet, und eine Sitzfläche (351), in die die zweite Ventilöffnung (37) öffnet,
wobei, um sicherzustellen, dass ein vorbestimmter Versetzungsbereich erzeugt wird, der Abstand (K7) zwischen den Sitzflächen(351, 851) unterschiedlich zu dem Abstand (H7) zwischen dem ersten Versetzungsübertragungsabschnitt (871) und dem zweiten Versetzungsübertragungsabschnitt (451) ist.

12. Steuerventil gemäß Anspruch 1,
dadurch gekennzeichnet, dass der erste Ventilkörper (39A) und der zweite Ventilkörper (68A) an dem hin- und herbeweglichen Körper (45A) befestigt sind, und
wobei dann, wenn der hin- und herbewegliche Körper (45A) sich in dem vorbestimmten Versetzungsbereich befindet, der erste Ventilkörper (39A) in die erste Ventilöffnung (36A) eintritt, um die erste Ventilöffnung (36A) zu schließen, und der zweite Ventilkörper (68A) in die zweite Ventilöffnung (37A) eintritt, um die zweite Ventilöffnung (37A) zu schließen.

13. Steuerventil gemäß Anspruch 12,
dadurch gekennzeichnet, dass der erste und der zweite Ventilkörper (39A, 68A) je einen ersten Erstkontaktabschnitt (396, 686) aufweisen und die Umfangsfläche von jeder Ventilöffnung (36A, 37A) einen zweiten Erstkontaktabschnitt (362, 372) aufweist,
wobei dann, wenn einer von dem ersten und dem zweiten Ventilkörper (39A, 68A) die korrespondierende Ventilöffnung (36A, 37A) von einem Öffnungszustand in einen Schließzustand schaltet, der erste Erstkontaktabschnitt (396, 686) von dem einen von dem ersten und dem zweiten Ventilkörper (39A, 68A) die Umfangsfläche von den Ventilöffnungen (36A, 37A) zuerst berührt, und der zweite Erstkontaktabschnitt (362, 372) der Ventilöffnung (36, 37), den ersten Erstkontaktabschnitt (396, 686) zuerst berührt, und
wobei, um sicherzustellen, dass ein vorbestimmter Versetzungsbereich erzeugt wird, der Abstand (H6) zwischen den ersten Erstkontaktabschnitten (396, 686) unterschiedlich zu dem Abstand (K6) zwischen den zweiten Erstkontaktabschnitten (362, 372) ist.

14. Steuerventil gemäß Anspruch 12 oder 13,
dadurch gekennzeichnet, dass der erste und der zweite Ventilkörper (39A, 68A) je einen abgeschrägten Abschnitt (395, 685) haben und wobei jeder abgeschrägte Abschnitt (395, 685) in die korrespondierende Ventilöffnung (36A, 37A) eintritt und aus dieser austritt.

15. Steuerventil gemäß Anspruch 14,
dadurch gekennzeichnet, dass, um sicherzustellen, dass ein vorbestimmter Versetzungsbereich erzeugt wird, der Abstand zwischen proximalen Enden der abgeschrägten Abschnitte (395, 685) unterschiedlich zu dem Abstand zwischen offenen Enden von der ersten und der zweiten Ventilöffnung (36A, 37A) ist.

16. Steuerventil gemäß einem der Ansprüche 1 bis 15,
dadurch gekennzeichnet, dass eine gemeinsam verwendete Kammer (38) zwischen der ersten Ventilöffnung (36) und der zweiten Ventilöffnung (37) festgelegt ist,
wobei die erste Ventilöffnung (36) und die zweite Ventilöffnung (37) die gemeinsam verwendete Kammer (38) öffnen, wobei die gemeinsam verwendete Kammer (38) mit der Steuerdruckkammer (30) in Verbindung steht, die erste Ventilöffnung (36) mit der Auslassdruckzone (132) in Verbindung steht und die zweite Ventilöffnung (37) mit der Saugdruckzone (131) in Verbindung steht, und
wobei dann, wenn der erste Ventilkörper (39) die erste Ventilöffnung (36) öffnet, die gemeinsam verwendete Kammer (38) durch die erste Ventilöffnung (36) mit der Auslassdruckzone (132) in Verbindung steht, und dann, wenn der zweite Ventilkörper (40) die zweite Ventilöffnung (37) öffnet, die gemeinsam verwendete Kammer (38) durch die zweite Ventilöffnung (37) mit der Saugdruckzone (131) in Verbindung steht.

17. Steuerventil gemäß einem der Ansprüche 1 bis 15, **dadurch gekennzeichnet, dass** die erste Ventilöffnung (36) mit der zweiten Ventilöffnung (37) verbunden ist,
wobei sich der hin- und herbewegliche Körper (45) durch die erste Ventilöffnung (36) und die zweite Ventilöffnung (37) erstreckt,
wobei der hin- und herbewegliche Körper (45) einen Separationsabschnitt (62) aufweist, der die zweite Ventilöffnung (37) von der ersten Ventilöffnung (36) trennt,
wobei die Steuerdruckkammer (121) durch die erste Ventilöffnung (36) mit der Auslassdruckzone (132) verbunden ist und durch die zweite Ventilöffnung (37) mit der Saugdruckzone (131) verbunden ist, und
wobei dann, wenn der erste Ventilkörper (39) die erste Ventilöffnung (36) öffnet, die Steuerdruckkammer (121) durch die erste Ventilöffnung (36) mit der Auslassdruckzone (132) in Verbindung steht, und dann, wenn der zweite Ventilkörper (40) die zweite Ventilöffnung (37) öffnet, die Steuerdruckkammer (121) durch die zweite Ventilöffnung (37) mit der Saugdruckzone (132) in Verbindung steht.

18. Steuerventil gemäß Anspruch 16 oder 17,
gekennzeichnet, durch

eine erste Auslassdruckkammer (98) und eine zweite Auslassdruckkammer (48), die mit der ersten (92) und der zweiten (94) Ventilöffnung zwischen diesen angeordnet sind,
wobei der hin- und herbewegliche Körper (45) ein erstes Ende, das sich **durch** die erste Ventilöffnung (92) erstreckt und den Druck von der ersten Auslassdruckkammer (98) aufnimmt, und ein zweites Ende aufweist, das sich durch die zweite Ventilöffnung (94) erstreckt und den Druck von der zweiten Auslassdruckkammer (48) aufnimmt, und wobei der Druck von der ersten Auslassdruckkammer (98) **durch** den hin- und herbeweglichen Körper (45) gegen den Druck der zweiten Auslassdruckkammer (48) wirkt.

19. Steuerventil gemäß Anspruch 16 oder 17, **gekennzeichnet, durch**
eine Auslassdruckeinführkammer (103), die dem Druck der Auslassdruckzone (132) ausgesetzt ist; und
einer Saugdruckeinführkammer (46, 104, 98A), die dem Druck der Saugdruckzone (131) ausgesetzt ist,
wobei die erste Ventilöffnung (36) und die zweite Ventilöffnung (37) zwischen der Auslassdruckeinführkammer (103) und der Saugdruckeinführkammer (46, 104, 98A), angeordnet sind,
wobei der hin- und herbewegliche Körper (45) ein erstes Ende, das sich **durch** die erste Ventilöffnung (36) erstreckt und den Druck von der Auslassdruckeinführkammer (103) aufnimmt, und ein zweites Ende aufweist, das sich durch die zweite Ventilöffnung (32) erstreckt und den Druck von der Saugdruckeinführkammer (46, 104, 98A) aufnimmt, und wobei der Druck von der Saugdruckeinführkammer (46, 104, 98A) gegen den Druck von der Auslassdruckeinführkammer (103) **durch** den hin- und herbeweglichen Körper (45) wirkt.

20. Steuerventil gemäß Anspruch 19,
gekennzeichnet, durch
einen Elektromagneten (41) zum Drängen des hin- und herbeweglichen Körpers (45) von der zweiten Ventilöffnung (37) zu der ersten Ventilöffnung (36) hin; und
eine erste Drängfeder (192) und eine zweite Drängfeder (56), die den hin- und herbeweglichen Körper (45) von der ersten Ventilöffnung (36) zu der zweiten Ventilöffnung (37) hin drängen.

21. Steuerventil gemäß einem der Ansprüche 1 bis 20, **gekennzeichnet, durch**
eine Steuerdruckeinführkammer (38), die dem Druck der Steuerdruckkammer (121) ausgesetzt ist,
wobei die Steuerdruckeinführkammer (38) zwischen der ersten Ventilöffnung (36) und der zweiten Ventilöffnung (37) festgelegt ist, wobei die Steuerdruckeinführkammer (38) die erste Ventilöffnung (36) mit der zweiten Ventilöffnung (37) verbindet,
wobei der Durchmesser der ersten Ventilöffnung (36) der gleiche wie der Durchmesser der zweiten Ventilöffnung (37) ist.

22. Steuerventil gemäß einem der Ansprüche 1 bis 20, **gekennzeichnet, durch**
eine erste Steuerdruckeinführzone (38) und eine zweite Steuerdruckeinführzone (98A), die dem Druck der Steuerdruckkammer (121) ausgesetzt sind, wobei die erste Steuerdruckeinführzone (38) zwischen der ersten Ventilöffnung (36) und der zweiten Ventilöffnung (37) festgelegt ist,
wobei die erste Ventilöffnung (36) die erste Steuerdruckeinführzone (38) öffnet,
wobei sich die zweite Ventilöffnung (37) zu der ersten Steuerdruckeinführzone (38) und der zweiten Steuerdruckeinführzone (98A) öffnet,
wobei die erste Steuerdruckeinführzone (38) mit der zweiten Steuerdruckeinführzone (98A) verbunden ist,
wobei der Druck der ersten Steuerdruckeinführzone (38) gegen den Druck der zweiten Steuerdruckeinführzone (98A) **durch** den hin- und herbeweglichen Körper (45) wirkt, und
wobei der Durchmesser von der ersten Ventilöffnung (38) unterschiedlich zu dem Durchmesser der zweiten Ventilöffnung (37) ist.

23. Steuerventil gemäß Anspruch 22,
dadurch gekennzeichnet, dass der Durchmesser der zweiten Ventilöffnung (37) größer als der Durchmesser der ersten Ventilöffnung (36) ist.

24. Steuerventil gemäß Anspruch 22 oder 23,
dadurch gekennzeichnet, dass sich die zweite Ventilöffnung (37) zu der Saugdruckzone (131) durch eine Durchgangsöffnung (105), die es dem hin- und herbeweglichen Körper (45) gestattet, sich dort hindurch zu erstrecken, und durch einen Verbindungsdurchgang (106) öffnet, der mit der Durchgangsöffnung (105) in Verbindung steht, und wobei beim Schließen der zweiten Ventilöffnung (37), der hin- und herbewegliche Körper (45) die zweite Steuerdruckeinführzone (98A) von dem Verbindungsdurchgang (106) trennt.

25. Steuerventil gemäß Anspruch 24,
dadurch gekennzeichnet, dass die Querschnittsfläche der Durchgangsöffnung (105) die gleiche wie die Querschnittsfläche der zweiten Ventilöffnung (37) ist.

26. Steuerventil gemäß Anspruch 24,
dadurch gekennzeichnet, dass eine Querschnittsfläche der zweiten Ventilöffnung (37) größer als die Querschnittsfläche der ersten Ventilöffnung (36) ist, und
wobei die Querschnittfläche der Durchgangsöffnung (105) die gleiche wie der Wert ist, der durch Subtrahieren der Querschnittsfläche der ersten Ventilöffnung (36) von der Querschnittfläche der zweiten Ventilöffnung (37) erhalten wird.

27. Steuerventil gemäß einem der Ansprüche 1 bis 17,
gekennzeichnet, durch einen Elektromagneten (41) zum Betätigen des hin- und herbeweglichen Körpers.

28. Steuerventil gemäß einem der Ansprüche 1 bis 18 und 27,
gekennzeichnet, durch:

ein Druckmessbauteil (54), das eine Druckdifferenz zwischen zwei Punkten in der Auslassdruckzone (132) oder eine Druckdifferenz zwischen zwei Punkten in der Saugdruckzone (131) erfasst, wobei das Druckmessbauteil (54) den hin- und herbeweglichen Körper (45) **durch** Verwenden der Druckdifferenz versetzt.

Revendications

1. Soupape (32) de commande de déplacement pour un compresseur (10) à déplacement variable, le compresseur (10) ayant:

une région (132) de pression de refoulement exposée à la pression d'un réfrigérant qui a été comprimé par le compresseur (10); une région (131) de pression d'aspiration exposée à la pression du réfrigérant qui est attiré dans le compresseur (10); une chambre (121) de pression de commande; un passage d'alimentation (26) qui relie la région (132) de pression de refoulement à la chambre (121) de pression de commande ; et un passage de refoulement (27) qui relie la région (131) de pression d'aspiration à la chambre (121) de pression de commande,

où la soupape de commande (32) régule la pression de la chambre (121) de pression de commande en fournissant du réfrigérant dans la région (132) de pression de refoulement à la chambre (121) de pression de commande à travers le passage d'alimentation (26) et en déchargeant le réfrigérant dans la chambre (121) de pression de commande à la région (131) de pression d'aspiration à travers le passage de refoulement (27), commandant ainsi le déplacement du compresseur, où la soupape de commande (32) comprend:

un premier trou de soupape (36; 36A; 92) formant une partie du passage d'alimentation (26);
un premier corps de soupape (39; 39A; 67; 67A; 90) qui ouvre et ferme de manière sélective le premier trou de soupape (36; 36A; 92);
un deuxième trou de soupape (37; 37A; 94) formant une partie du passage de refoulement;
un deuxième corps de soupape (40; 40A; 68; 68A; 68B; 89) qui ouvre et ferme de manière sélective le deuxième trou de soupape (37; 37A; 94); et
un corps (45) en mouvement de va-et-vient qui peut se déplacer et avoir un mouvement de va-et-vient, où le déplacement du corps (45) en mouvement de va-et-vient est transmis à chacun des premier (39; 39A; 68) et deuxième (40, 67) corps de soupape de sorte que chaque corps de soupape ouvre ou ferme le trou de soupape correspondant;
la soupape de commande étant **caractérisée en ce que**:

lorsque le corps (45) en mouvement de va-et-vient se trouve dans une plage de déplacement prédéterminée, un état de double fermeture, dans lequel le premier corps de soupape (39; 39A; 67; 67A; 90) ferme le premier trou de soupape (36; 36A; 92) et le deuxième corps de soupape (40; 40A; 68 ; 68A; 68B ; 89) ferme le deuxième trou de soupape (37; 37A; 94), se produit.

où, lorsque le corps (45) en mouvement de va-et-vient est en-dehors de la plage de déplacement, un état de simple fermeture, dans lequel uniquement l'un du premier corps de soupape (39; 39A; 67; 67A; 90) et du deuxième corps de soupape (40; 40A; 68; 68A; 68B; 89) ferme le trou de soupape correspondant des trous de soupape, se produit.

2. Soupape de commande selon la revendication 1, **caractérisée par** :

un mécanisme de changement de distance qui change la distance entre le premier corps de soupape (39; 39A; 67; 67A; 90) et le deuxième corps de soupape (40; 40A; 68; 68A; 89) selon la position du corps (45) en mouvement de va-et-vient lorsque le corps (45) en mouvement de va-et-vient se déplace, amenant ainsi l'état de double fermeture ou l'état de simple fermeture à se produire, et où, lorsque l'un des premier et deuxième corps de soupape au moins se trouve à une position spécifique et ferme le trou de soupape correspondant, le mécanisme de changement de distance permet au corps (45) en mouvement de va-et-vient de se déplacer par rapport au corps de soupape à la position spécifique.

3. Soupape de commande selon la revendication 2, **caractérisée en ce que** l'un des premier et deuxième corps de soupape uniquement est un corps de soupape fixe (39; 39A; 68; 68A) qui est fixé au corps (45) en mouvement de va-et-vient, et où, lorsque le corps (45) en mouvement de va-et-vient se trouve dans la plage de déplacement prédéterminée, le corps de soupape fixe (39; 39A; 68; 68A) rentre dans le trou de soupape (36; 37) qui correspond au corps de soupape fixe (39; 39A; 68; 68A) pour fermer le trou de soupape (36; 37).

4. Soupape de commande selon la revendication 3, **caractérisée en ce que** le corps de soupape fixe (39; 39A; 68; 68A) contient une partie fuselée (392; 395; 682; 685) qui rentre dans et sort du trou de soupape correspondant (36; 37).

5. Soupape de commande selon la revendication 3, **caractérisée en ce qu'**une ouverture (363; 364; 373; 374) du trou de soupape (36; 37) qui correspond au corps de soupape fixe (39; 39A; 68; 68A) s'étend vers le corps de soupape fixe (39; 39A; 68; 68A).

6. Soupape de commande selon l'une quelconque des revendications 3 à 5, **caractérisée en ce que** l'un des premier et deuxième corps de soupape qui n'est pas le corps de soupape fixe (39; 39A; 68; 68A) est un corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89) qui est ajusté de manière coulissante au corps (45) en mouvement de va-et-vient,
où le corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89) peut se déplacer entre une position de fermeture pour fermer le trou de soupape correspondant (36; 37) et une position d'ouverture pour ouvrir le trou de soupape (36; 37),
où le corps (45) en mouvement de va-et-vient comprend une partie de transmission de déplacement (451; 721; 456; 457; 871) qui entre en contact avec le corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89) pour transmettre le déplacement du corps (45) en mouvement de va-et-vient au corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89), déplaçant ainsi le corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89) de la position de fermeture vers la position d'ouverture, et
où le mécanisme de changement de distance comprend la partie de transmission de déplacement (451; 721; 456; 457; 871) et un organe de sollicitation (47; 71; 82; 84; 86) pour solliciter le corps de soupape coulissant (40; 40A; 67; 67A; 67B; 90; 89) vers la partie de transmission de déplacement (451; 721; 456; 457; 871).

7. Soupape de commande selon la revendication 6, **caractérisée par** une face d'assise (351; 691; 771; 772; 851; 911; 931) dans laquelle un trou de soupape (37; 36), qui correspond au corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89), s'ouvre,
où le corps de soupape coulissant (40; 40A; 67; 67A; 40B; 67B; 90; 89) dispose d'une face (403; 673; 893; 903) de fermeture de soupape qui entre en contact avec la face d'assise (351; 691; 771; 772; 851; 911; 931) pour fermer le trou de soupape correspondant (37; 36), la partie de transmission de déplacement (451; 721; 456; 457; 871) pouvant entrer en contact avec la face (403; 673; 893; 903) de fermeture de soupape,
où le corps de soupape fixe (39; 39A; 68; 68A) dispose d'une première partie (393; 396; 683; 686) de contact initial, et la surface circonférentielle du trou de soupape (36; 37) qui correspond au corps de soupape fixe (39; 39A; 68; 68A) dispose d'une deuxième partie (361; 371) de contact initial, où, lorsque le corps de soupape fixe commute le trou de soupape correspondant (36; 37) d'un état ouvert à un état fermé, la première partie (393; 396; 683; 686) de contact initial entre initialement en contact avec la surface circonférentielle du trou de soupape correspondant (36; 37), et la deuxième partie (361; 371) de contact initial entre initialement en contact avec la première partie (393; 396; 683; 686) de contact initial, et
où, afin d'assurer la création d'une plage de déplacement prédéterminée, la distance (H2 ; H2) entre la partie de

transmission de déplacement (451; 721; 456; 457; 871) et la première partie (393; 396; 683; 686) de contact initial est différente de la distance (K1; K2) entre la deuxième partie (361; 371) de contact initial et la face d'assise (351; 691; 771; 772; 851; 911; 931).

8. Soupape de commande selon la revendication 6, **caractérisée par** une face d'assise dans laquelle un trou de soupape (37), qui correspond au corps de soupape coulissant (40B), s'ouvre,
où le corps de soupape coulissant (40B) dispose d'une face (403) de fermeture de soupape qui entre en contact avec la face d'assise correspondante (351) pour fermer le trou de soupape correspondant (37), et une face (402) de réception de déplacement qui peut entrer en contact avec la partie (459) de transmission de déplacement, la face (403) de fermeture de soupape et la face (402) de réception de déplacement étant séparées l'une de l'autre par rapport à une direction de déplacement du corps (45) en mouvement de va-et-vient, où le corps de soupape fixe (39) dispose d'une première partie (393) de contact initial, et la surface circonférentielle du trou de soupape (36) qui correspond au corps de soupape fixe (39) dispose d'une deuxième partie (361) de contact initial,
où, lorsque le corps de soupape fixe (39) commute le trou de soupape correspondant (36) d'un état ouvert en un état fermé, la première partie (393) de contact initial entre initialement en contact avec la surface circonférentielle du trou de soupape correspondant (36), et la deuxième partie (361) de contact initial entre initialement en contact avec la première partie (393) de contact initial, et
où, afin d'assurer la création d'une plage de déplacement prédéterminée, la somme de la distance (H11) entre la partie (459) de transmission de déplacement et la première partie (393) de contact initial et la distance (H12) entre la face (403) de fermeture de soupape et la face (402) de réception de déplacement est différente de la distance (K1) entre la deuxième partie (361) de contact initial et la face d'assise (351).

9. Soupape de commande selon la revendication 8, **caractérisée en ce que** le corps de soupape coulissant dispose d'un évidement (401), un trou à travers lequel s'étend le corps (45) en mouvement de va-et-vient, celui-ci étant formé dans une partie inférieure de l'évidement (401), et
où une extrémité ouverte de l'évidement (401) forme la face (403) de fermeture de soupape, et la partie inférieure de l'évidement forme la face (459) de réception de déplacement.

10. Soupape de commande selon la revendication 2, **caractérisée en ce que** le premier corps de soupape (67) et le deuxième corps de soupape (40) sont ajustés de manière coulissante au corps (45) en mouvement de va-et-vient, et où le corps (45) en mouvement de va-et-vient contient :

> une première partie (871) de transmission de déplacement qui entre en contact avec le premier corps de soupape (67) pour transmettre le déplacement du corps (45) en mouvement de va-et-vient au premier corps de soupape (67), déplaçant ainsi le premier corps de soupape (67) de la partie de fermeture à la partie d'ouverture, et
> une deuxième partie (451) de transmission de déplacement qui entre en contact avec le deuxième corps de soupape (40) pour transmettre le déplacement du corps (45) en mouvement de va-et-vient au deuxième corps de soupape (40), déplaçant ainsi le deuxième corps de soupape (40) de la position de fermeture vers la position d'ouverture,

où le mécanisme de changement de distance comprend la première partie (871) de transmission de déplacement, la deuxième partie (451) de transmission de déplacement, un premier organe de sollicitation (99) pour solliciter le premier corps de soupape (67) vers la première partie (871) de transmission de déplacement, et un deuxième organe de sollicitation (86) pour solliciter le deuxième corps de soupape (40) vers la deuxième partie (451) de transmission de déplacement.

11. Soupape de commande selon la revendication 10, **caractérisée par** une face d'assise (851) dans laquelle s'ouvre le premier trou de soupape (36) et une face d'assise (351) dans laquelle s'ouvre le deuxième trou de soupape (37), où, afin d'assurer la création d'une plage de déplacement prédéterminée, la distance (K7) entre les faces d'assise (351, 851) est différente de la distance (H7) entre la première partie (871) de transmission de déplacement et la deuxième partie (451) de transmission de déplacement.

12. Soupape de commande selon la revendication 1, **caractérisée en ce que** le premier corps de soupape (39A) et le deuxième corps de soupape (68A) sont fixés au corps (45A) en mouvement de va-et-vient, et
où, lorsque le corps (45A) en mouvement de va-et-vient se trouve dans la plage de déplacement prédéterminée, le premier corps de soupape (39A) rentre dans le premier trou de soupape (36A) pour fermer le premier trou de soupape (36A), et le deuxième corps de soupape (68A) rentre dans le deuxième trou de soupape (37A) pour fermer

le deuxième trou de soupape (37A).

13. Soupape de commande selon la revendication 12, **caractérisée en ce que** les premier et deuxième corps de soupape (39A, 68A) ont chacun une première partie (396, 686) de contact initial, et la surface circonférentielle de chaque trou de soupape (36A, 37A) dispose d'une deuxième partie (362, 372) de contact initial,
où, lorsque l'un des premier et deuxième corps de soupape (39A, 68A) commute le trou de soupape correspondant (36A, 37A) d'un état ouvert en un état fermé, la première partie (396, 686) de contact initial de l'un des premier et deuxième corps de soupape (39A, 68A) entre initialement en contact avec la surface circonférentielle des trous de soupape (36A, 37A), et la deuxième partie (362, 372) de contact initial du trou de soupape (36, 37) entre initialement en contact avec la première partie (396, 686) de contact initial, et
où, afin d'assurer la création d'une plage de déplacement prédéterminée, la distance (H6) entre les premières parties (396, 686) de contact initial est différente de la distance (K6) entre les deuxièmes parties (362, 372) de contact initial.

14. Soupape de commande selon la revendication 12 ou 13, **caractérisée en ce que** les premier et deuxième corps de soupape (39A, 68A) ont chacun une partie fuselée (395, 685), et où chaque partie fuselée (395, 685) rentre dans et sort du trou de soupape correspondant (36A, 37A).

15. Soupape de commande selon la revendication 14, **caractérisée en ce que**, afin d'assurer la création d'une plage de déplacement prédéterminée, la distance entre les extrémités proximales des parties fuselées (395, 685) est différente de la distance entre les extrémités ouvertes des premier et deuxième trous de soupape (36A, 37A).

16. Soupape de commande selon l'une quelconque des revendications 1 à 15,
caractérisée en ce qu'une chambre cisaillée (38) est définie entre le premier trou de soupape (36) et le deuxième trou de soupape (37), le premier trou de soupape (36) et le deuxième trou de soupape (37) ouvrant la chambre cisaillée (38),
où la chambre cisaillée (38) communique avec la chambre (30) de pression de commande, le premier trou de soupape (36) communique avec la région (132) de pression de refoulement, et le deuxième trou de soupape (37) communique avec la région (131) de pression d'aspiration, et
où, lorsque le premier corps de soupape (39) ouvre le premier trou de soupape (36), la chambre cisaillée (38) communique avec la région (132) de pression de refoulement à travers le premier trou de soupape (36), et, lorsque le deuxième corps de soupape (40) ouvre le deuxième trou de soupape (37), la chambre cisaillée (38) communique avec la région (131) de pression d'aspiration à travers le deuxième trou de soupape (37).

17. Soupape de commande selon l'une quelconque des revendications 1 à 15,
caractérisée en ce que le premier trou de soupape (36) est relié au deuxième trou de soupape (37), le corps (45) en mouvement de va-et-vient s'étendant à travers le premier trou de soupape (36) et le deuxième trou de soupape (37),
où le corps (45) en mouvement de va-et-vient dispose d'une partie de séparation (62) qui sépare le deuxième trou de soupape (37) du premier trou de soupape (36),
où la chambre (121) de pression de commande est reliée à la région (132) de pression de refoulement à travers le premier trou de soupape (36), et est reliée à la région (131) de pression d'aspiration à travers le deuxième trou de soupape (37), et
où, lorsque le premier corps de soupape (39) ouvre le premier trou de soupape (36), la chambre (121) de pression de commande communique avec la région (132) de pression de refoulement à travers le premier trou de soupape (36), et, lorsque le deuxième corps de soupape (40) ouvre le deuxième trou de soupape (37), la chambre (121) de pression de commande communique avec la région (131) de pression d'aspiration à travers le deuxième trou de soupape (37).

18. Soupape de commande selon la revendication 16 ou 17, **caractérisée par** :

une première chambre (98) de pression de refoulement et une deuxième chambre (48) de pression de refoulement, qui sont agencées avec les premier (92) et deuxième (94) trous de soupape entre les deux,

où le corps (45) en mouvement de va-et-vient dispose d'une première extrémité qui s'étend à travers le premier trou de soupape (92) et reçoit la pression de la première chambre (98) de pression de refoulement, et une deuxième extrémité qui s'étend à travers le deuxième trou de soupape (94) et reçoit la pression de la deuxième chambre (48) de pression de refoulement, et où la pression de la première chambre (98) de pression de refoulement agit contre la pression de la deuxième chambre (48) de pression de refoulement à travers le corps (45) en mouvement de va-et-vient.

19. Soupape de commande selon la revendication 16 ou 17, **caractérisée par** :

une chambre (103) d'introduction de pression de refoulement qui est exposée à la pression de la région (132) de pression de refoulement ; et
une chambre (46, 104, 98A) d'introduction de pression d'aspiration qui est exposée à la pression de la région (131) de pression d'aspiration,
où le premier trou de soupape (92) et le deuxième trou de soupape (37) sont agencés entre la chambre (103) d'introduction de pression de refoulement et la chambre (46, 104, 98A) d'introduction de pression d'aspiration,
où le corps (45) en mouvement de va-et-vient dispose d'une première extrémité qui s'étend à travers le premier trou de soupape (36) et reçoit la pression de la chambre (103) d'introduction de pression de refoulement, et une deuxième extrémité qui s'étend à travers le deuxième trou de soupape (37) et reçoit la pression de la chambre (46, 104, 98A) d'introduction de pression d'aspiration, et
où la pression de la chambre (46, 104, 98A) d'introduction de pression d'aspiration agit contre la pression de la chambre (103) d'introduction de pression de refoulement à travers le corps (45) en mouvement de va-et-vient.

20. Soupape de commande selon la revendication 19, **caractérisée par** :

un solénoïde (41) pour solliciter le corps (45) en mouvement de va-et-vient du deuxième trou de soupape (37) vers le premier trou de soupape (36) ; et
un premier ressort de sollicitation (102) et un deuxième ressort de sollicitation (56) qui sollicitent le corps (45) en mouvement de va-et-vient du premier trou de soupape (36) vers le deuxième trou de soupape (37).

21. Soupape de commande selon l'une quelconque des revendications 1 à 20, **caractérisée par** :

une chambre (38) d'introduction de pression de commande qui est exposé à la pression de la chambre (121) de pression de commande,
où la chambre (38) d'introduction de pression de commande est définie entre le premier trou de soupape (36) et le deuxième trou de soupape (37), la chambre (38) d'introduction de pression de commande reliant le premier trou de soupape (36) et le deuxième trou de soupape (37),
où le diamètre du premier trou de soupape (36) est le même que le diamètre du deuxième trou de soupape (37).

22. Soupape de commande selon l'une quelconque des revendications 1 à 20, **caractérisée par** :

une première région (38) d'introduction de pression de commande et une deuxième région (98A) d'introduction de pression de commande qui sont exposées à la pression de la chambre (121) de pression de commande,
où la première région (38) d'introduction de pression de commande est définie entre le premier trou de soupape (36) et le deuxième trou de soupape (37),
où le premier trou de soupape (36) ouvre la première région (38) d'introduction de pression de commande,
où le deuxième trou de soupape (37) ouvre la première région (38) d'introduction de pression de commande et la deuxième région (98A) d'introduction de pression de commande,
où la première région (38) d'introduction de pression de commande est reliée à la deuxième région (98A) d'introduction de pression de commande,
où la pression de la première région (38) d'introduction de pression de commande agit contre la pression de la deuxième région (98A) d'introduction de pression de commande à travers le corps (45) en mouvement de va-et-vient, et
où le diamètre du premier trou de soupape (36) est différent du diamètre du deuxième trou de soupape (37).

23. Soupape de commande selon la revendication 22, **caractérisée en ce que** le diamètre du deuxième trou de soupape (37) est supérieur au diamètre du premier trou de soupape (36).

24. Soupape de commande selon la revendication 22 ou 23,
caractérisée en ce que le deuxième trou de soupape (37) ouvre la région (131) de pression d'aspiration à travers un trou traversant (105) qui permet au corps (45) en mouvement de va-et-vient de s'étendre à travers celui-ci et un passage de communication (106) qui communique avec le trou traversant (105), et
où, la fermeture du deuxième trou de soupape (37), le corps (45) en mouvement de va-et-vient rompt la liaison

entre la deuxième région (98A) d'introduction de pression de commande et le passage de communication (106).

25. Soupape de commande selon la revendication 24,
caractérisée en ce que la surface en coupe transversale du trou traversant (105) est la même que la surface en coupe transversale du deuxième trou de soupape (37).

26. Soupape de commande selon la revendication 24,
caractérisée en ce que la surface en coupe transversale du deuxième trou de soupape (37) est plus grande que la surface en coupe transversale du premier trou de soupape (36), et
où la surface en coupe transversale du trou traversant (105) est la même que la valeur obtenue en soustrayant la surface en coupe transversale du premier trou de soupape (36) de la surface en coupe transversale du deuxième trou de soupape (37).

27. Soupape de commande selon l'une quelconque des revendications 1 à 17,
caractérisée par un solénoïde (41) conçu pour actionner le corps en mouvement de va-et-vient.

28. Soupape de commande selon l'une quelconque des revendications 1 à 18 et 27,
caractérisée par :

un organe (54) de détection de pression qui détecte une différence de pression entre deux points dans la région (132) de pression de refoulement ou une différence de pression entre deux points dans la région (131) de pression d'aspiration, où l'organe (54) de détection de pression déplace le corps (45) en mouvement de va-et-vient en utilisant la différence de pression.

Fig.1

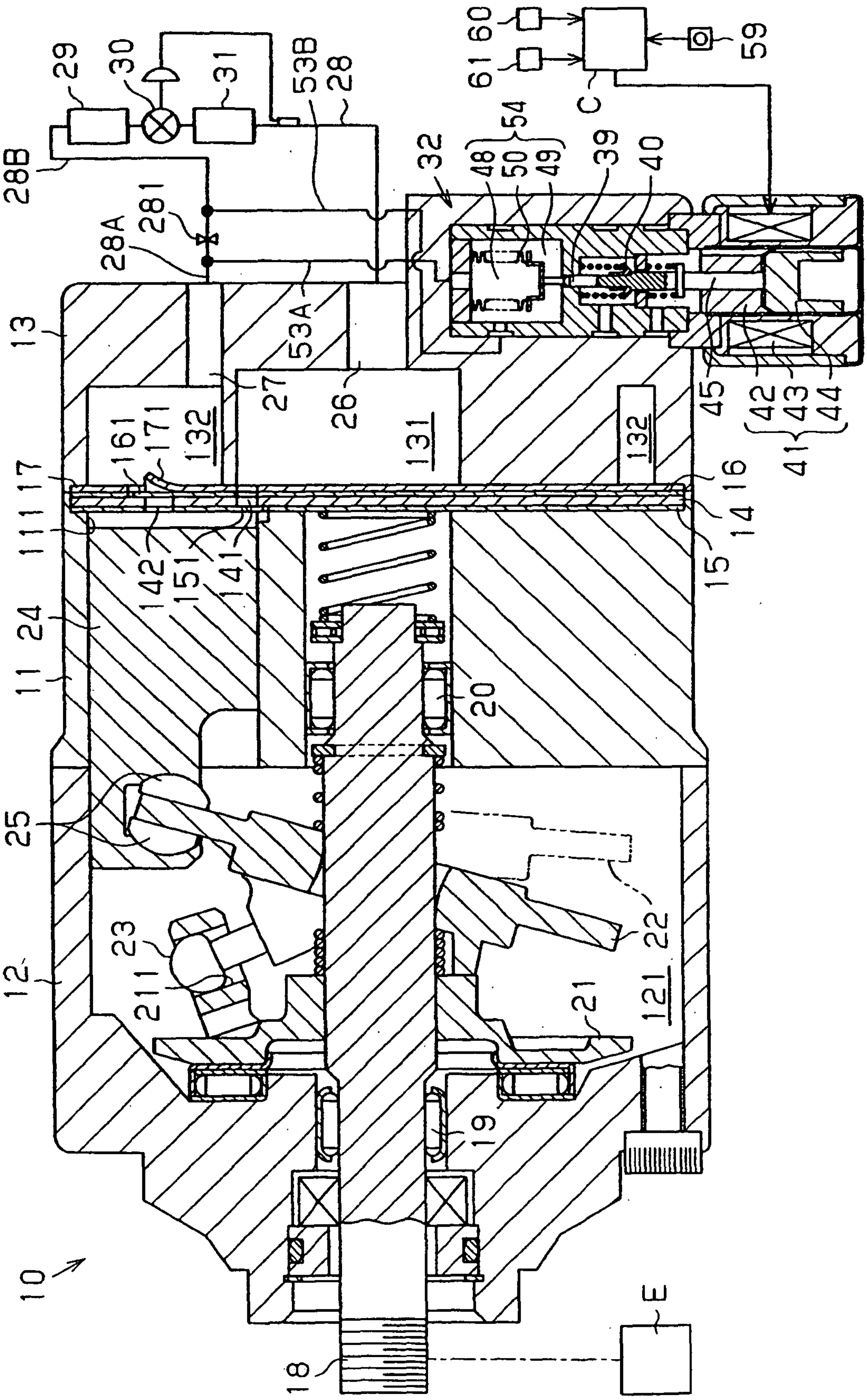
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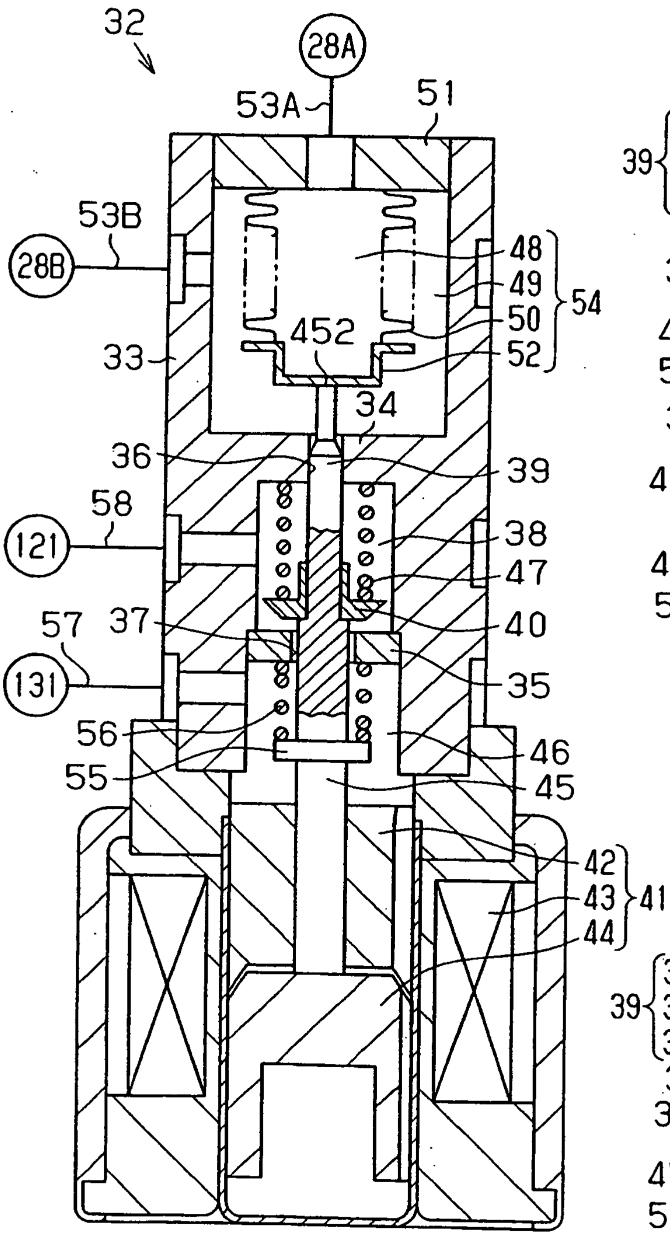
Fig.2(a)



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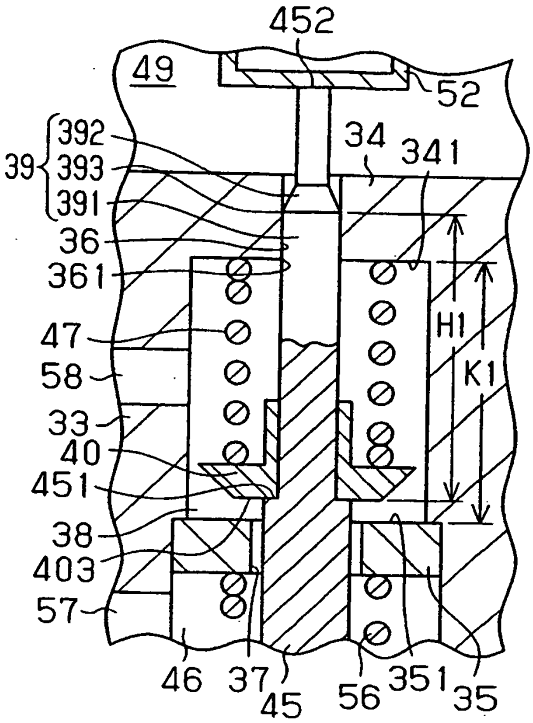

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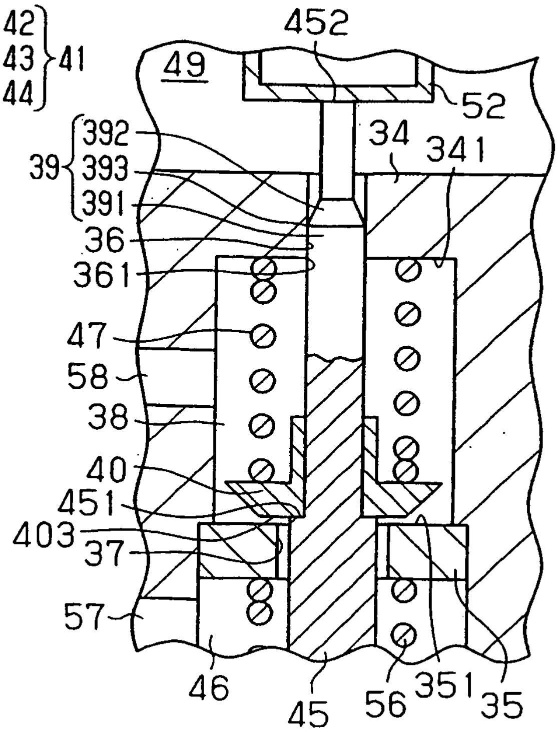

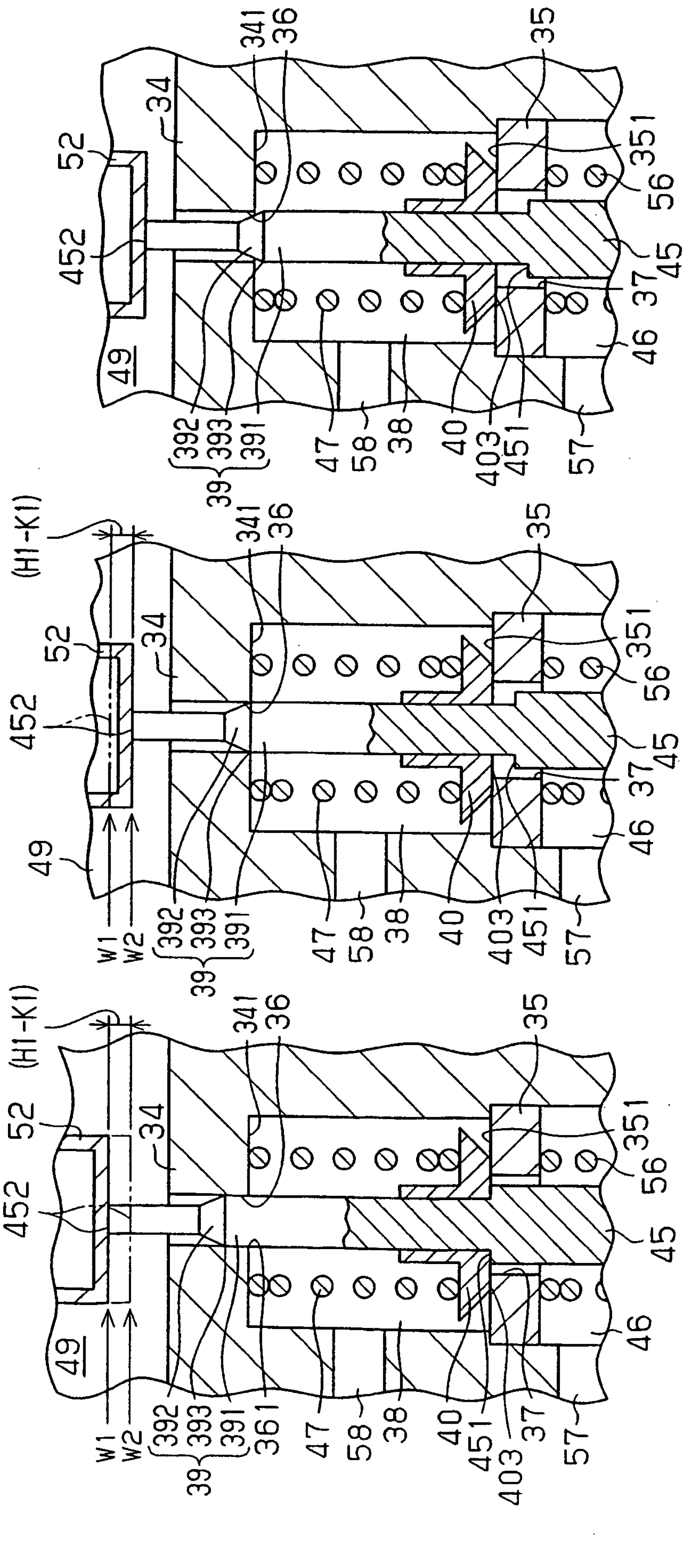

Fig.3(a)

Fig.3(b)

Fig.3(c)

Fig.4(a)

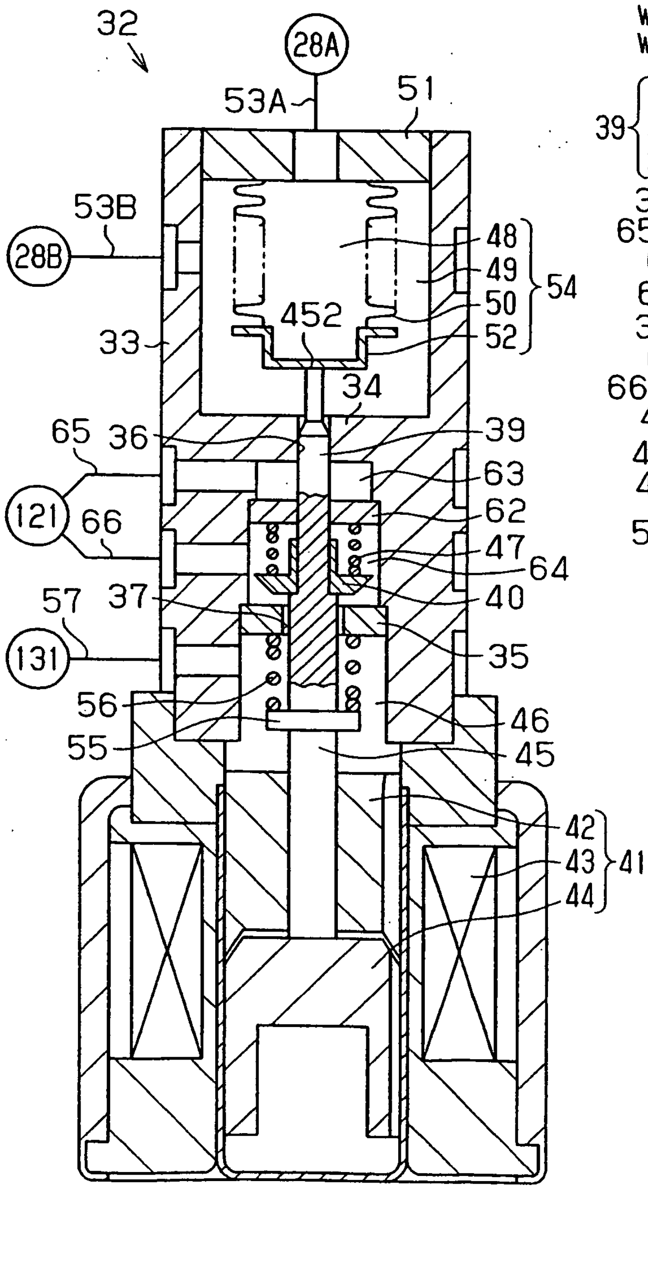
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Fig.4(b)

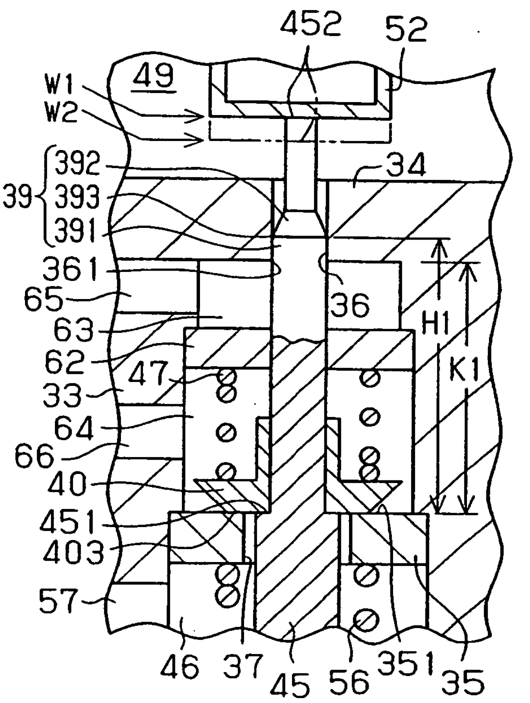
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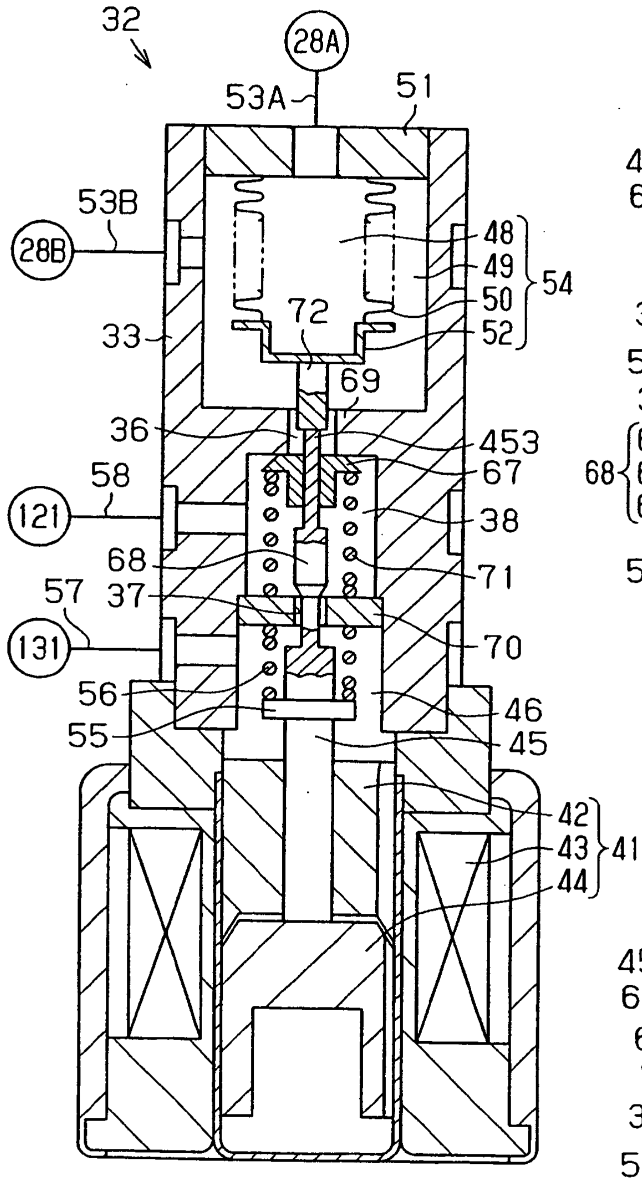
Fig.5(a)



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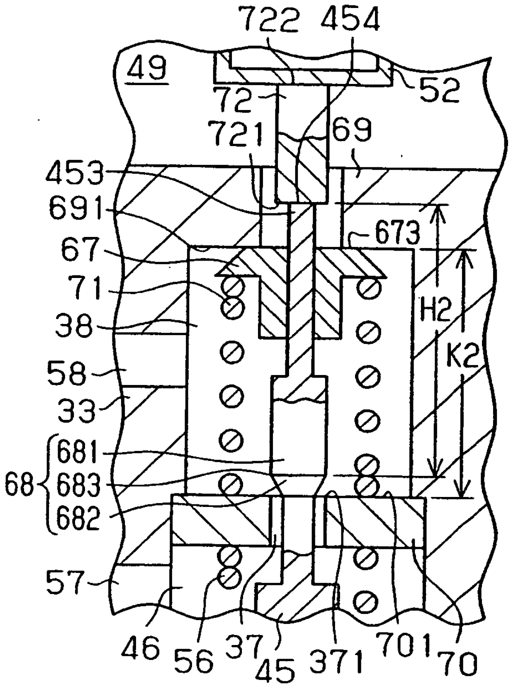

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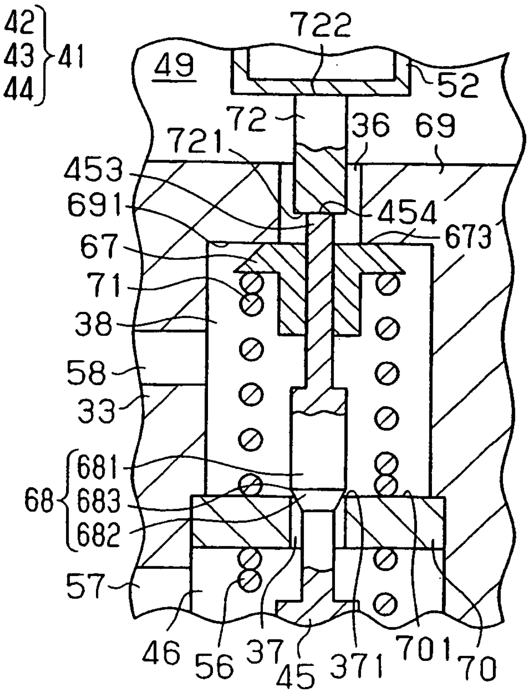


Fig.6(a)

Fig.6(b)

Fig.6(c)

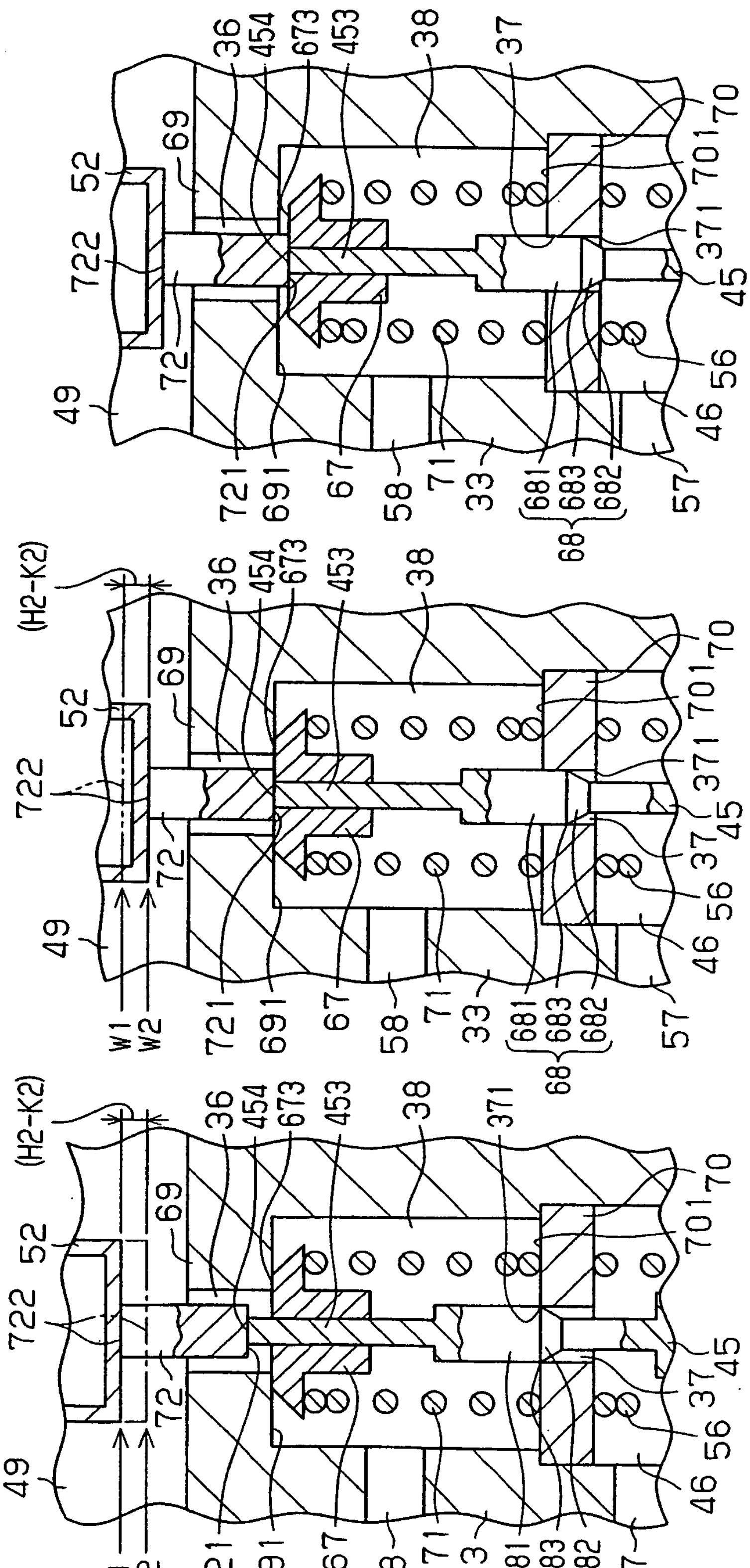


Fig.7

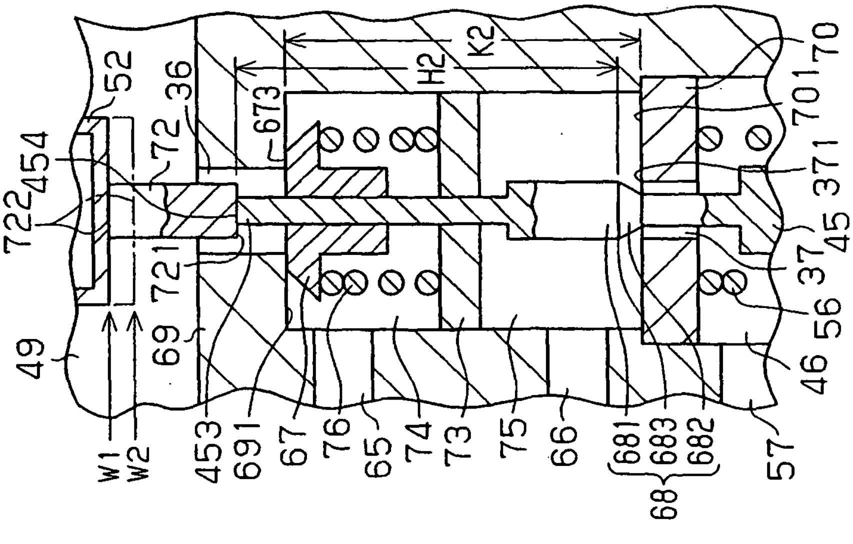
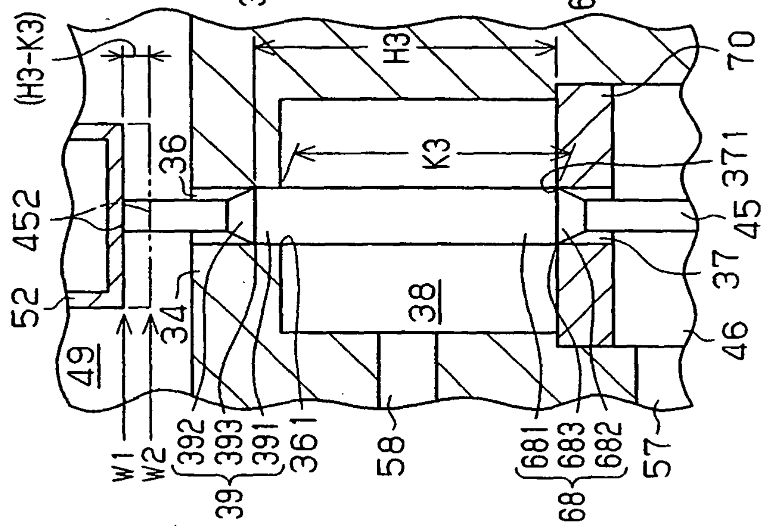


Fig.8(a)



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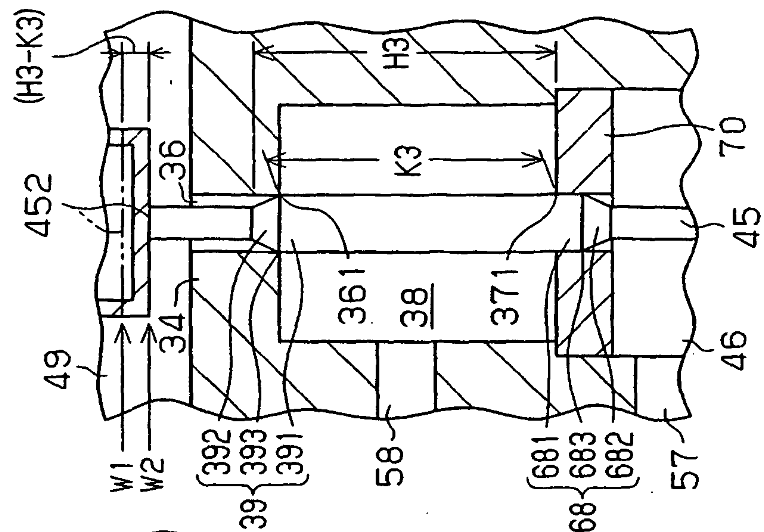
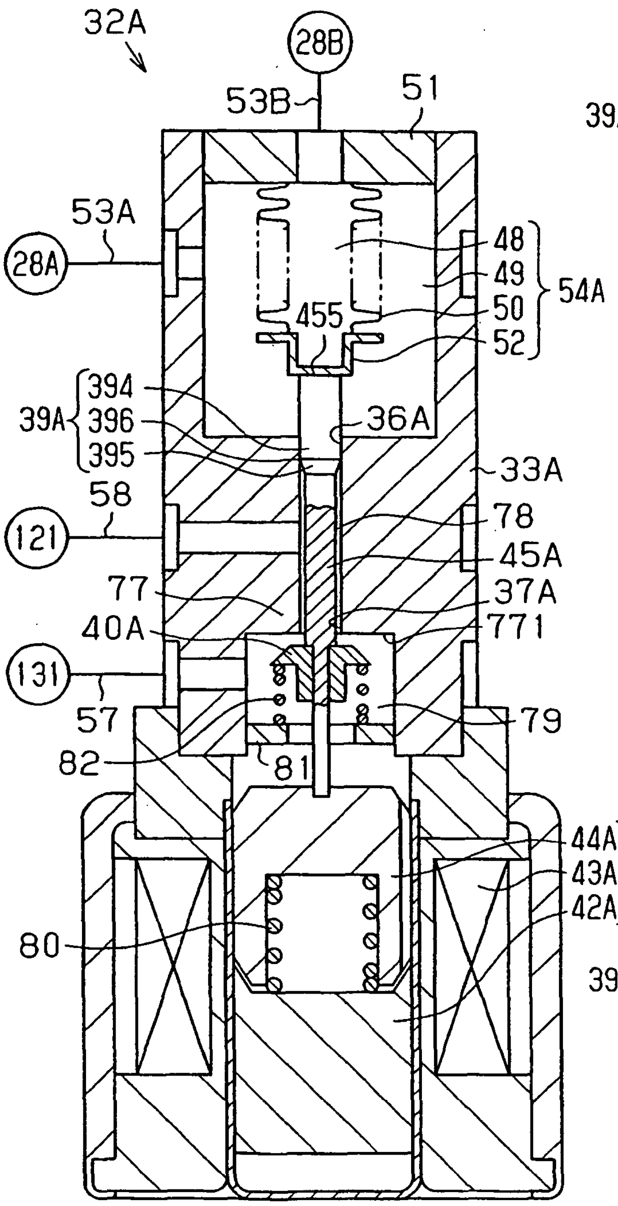


Fig.9(a)



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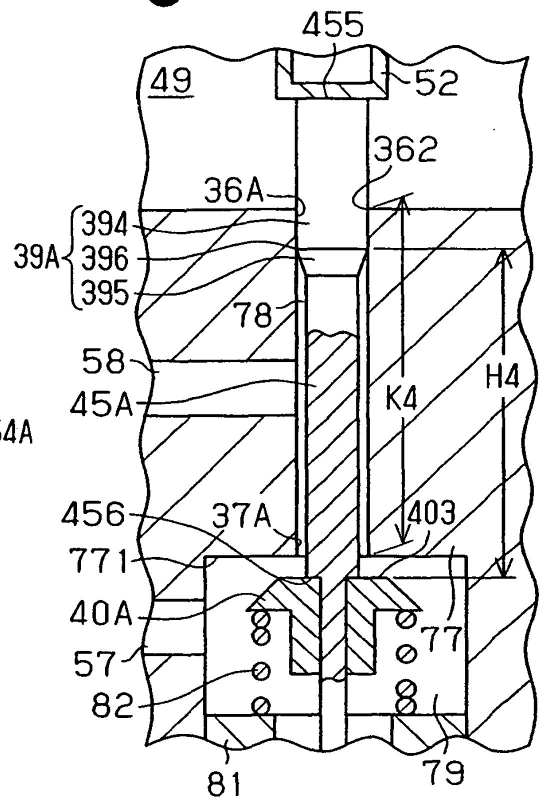

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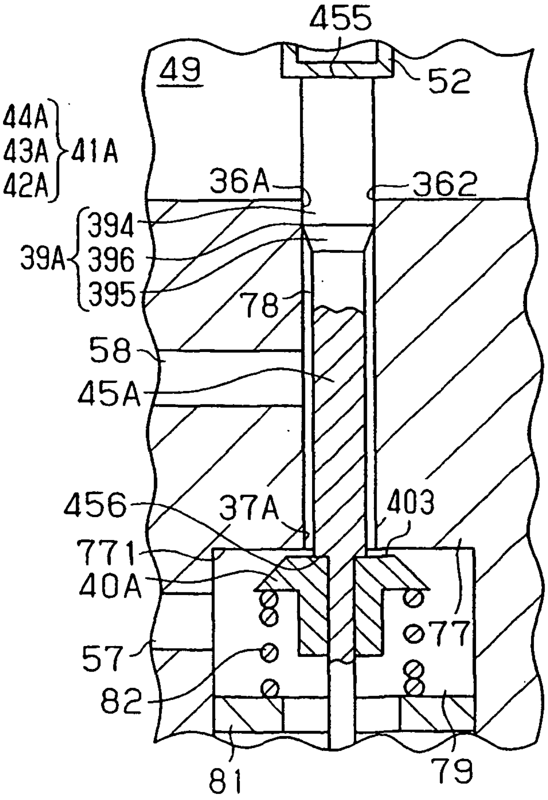


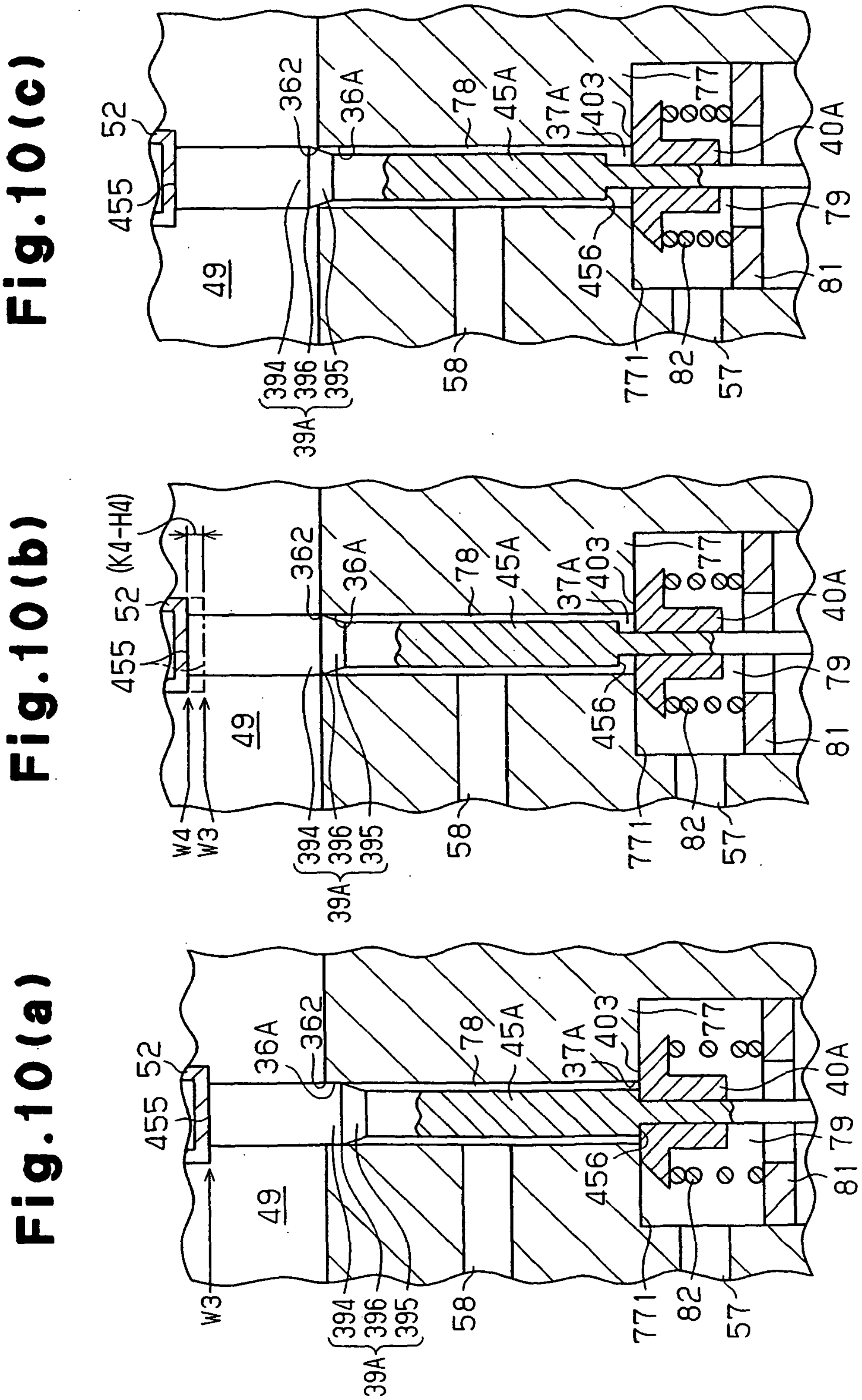


Fig.10(a)

Fig.10(b)

Fig.10(c)

Fig.11 (a)

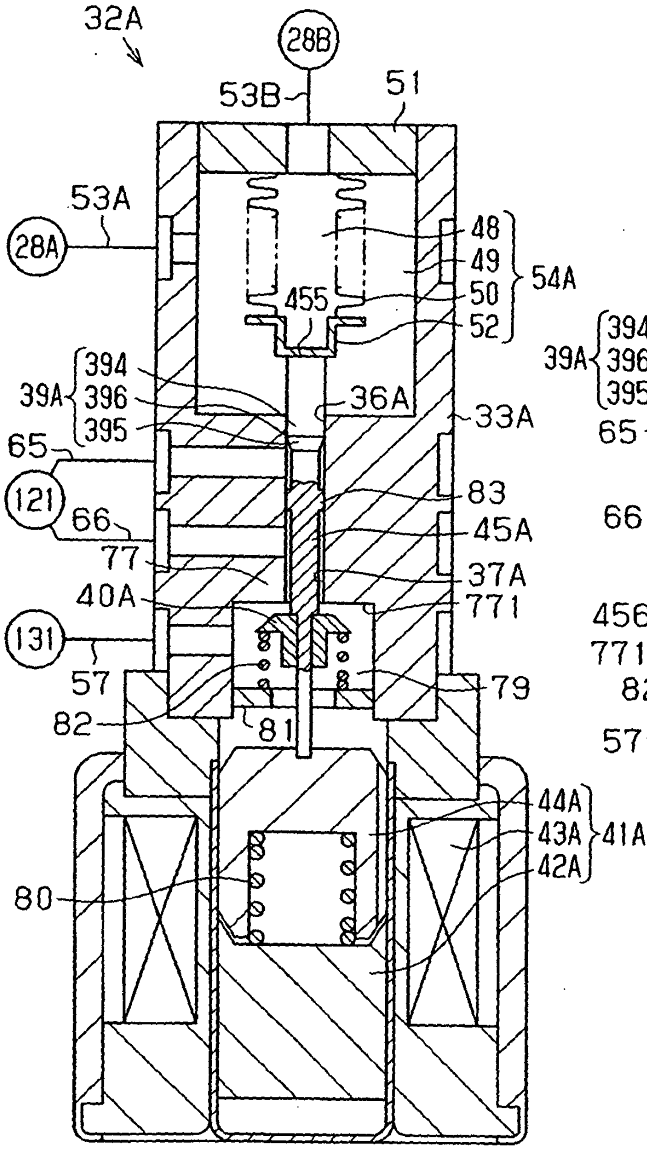


Fig.11 (b)

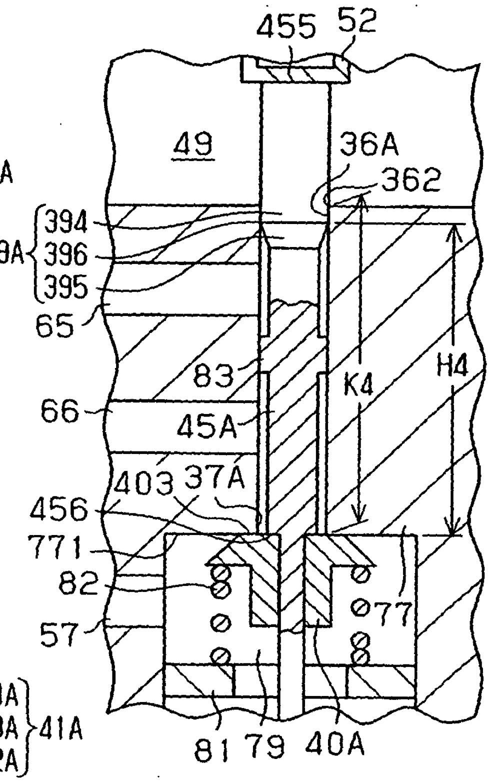


Fig.12(a)

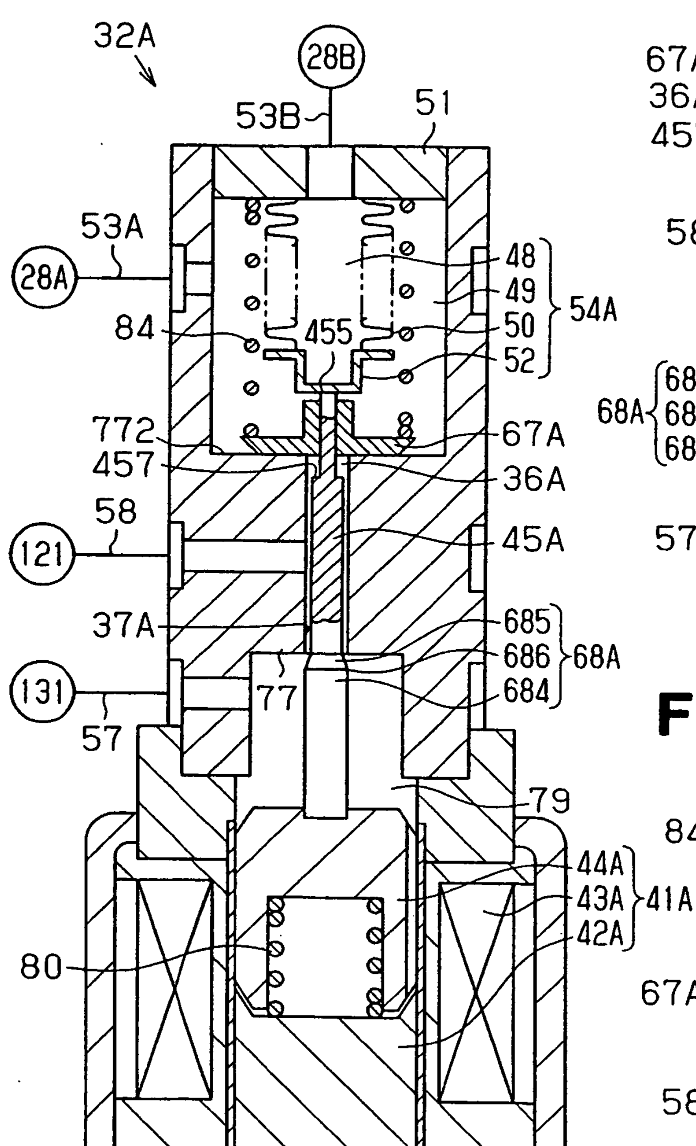


Fig.12(b)

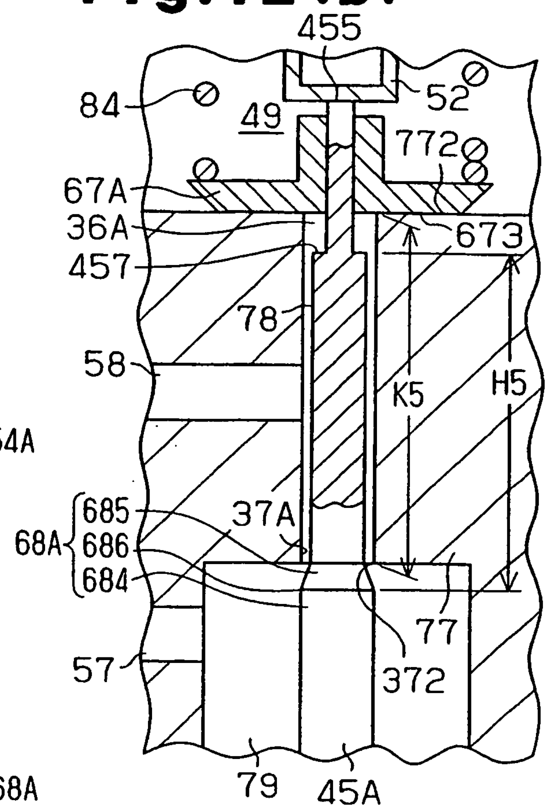
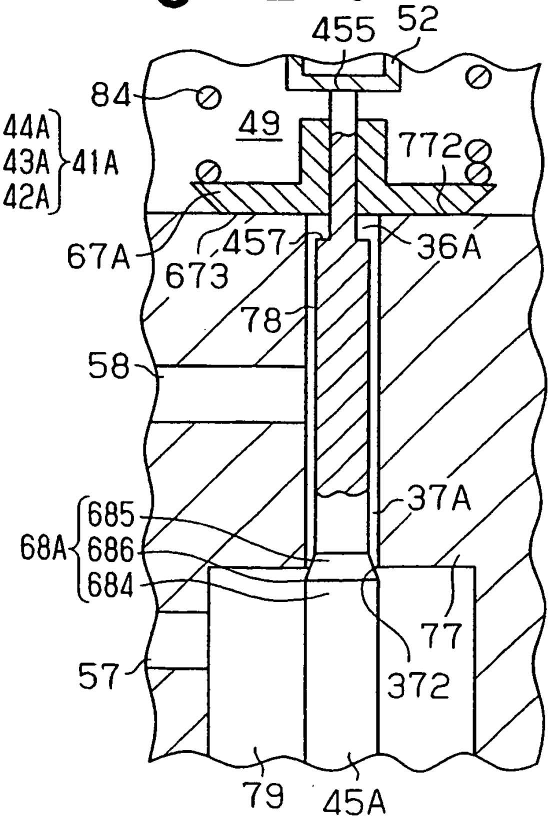


Fig.12(c)



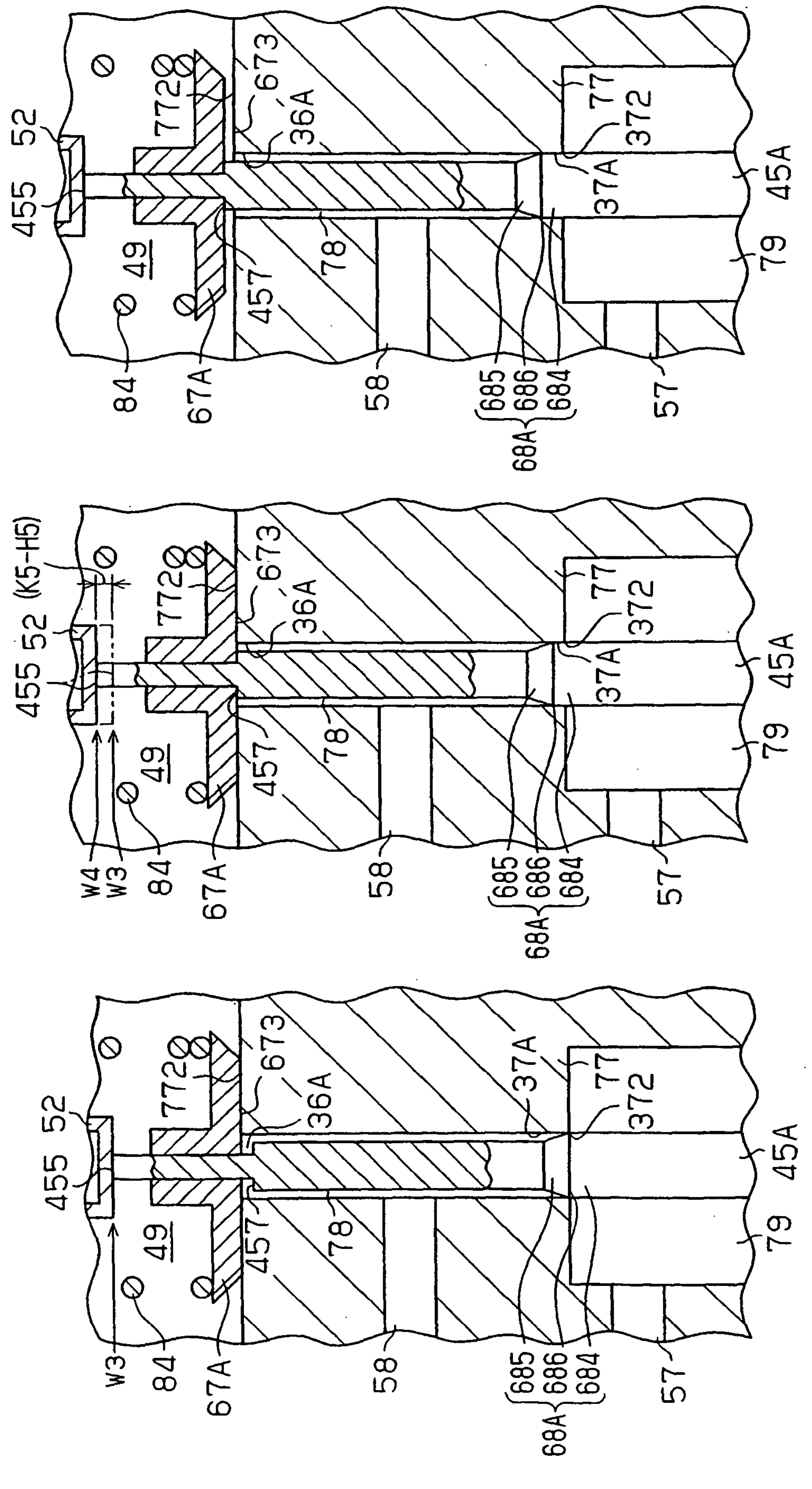


Fig.13(a)

Fig.13(b)

Fig.13(c)

Fig.14(a)

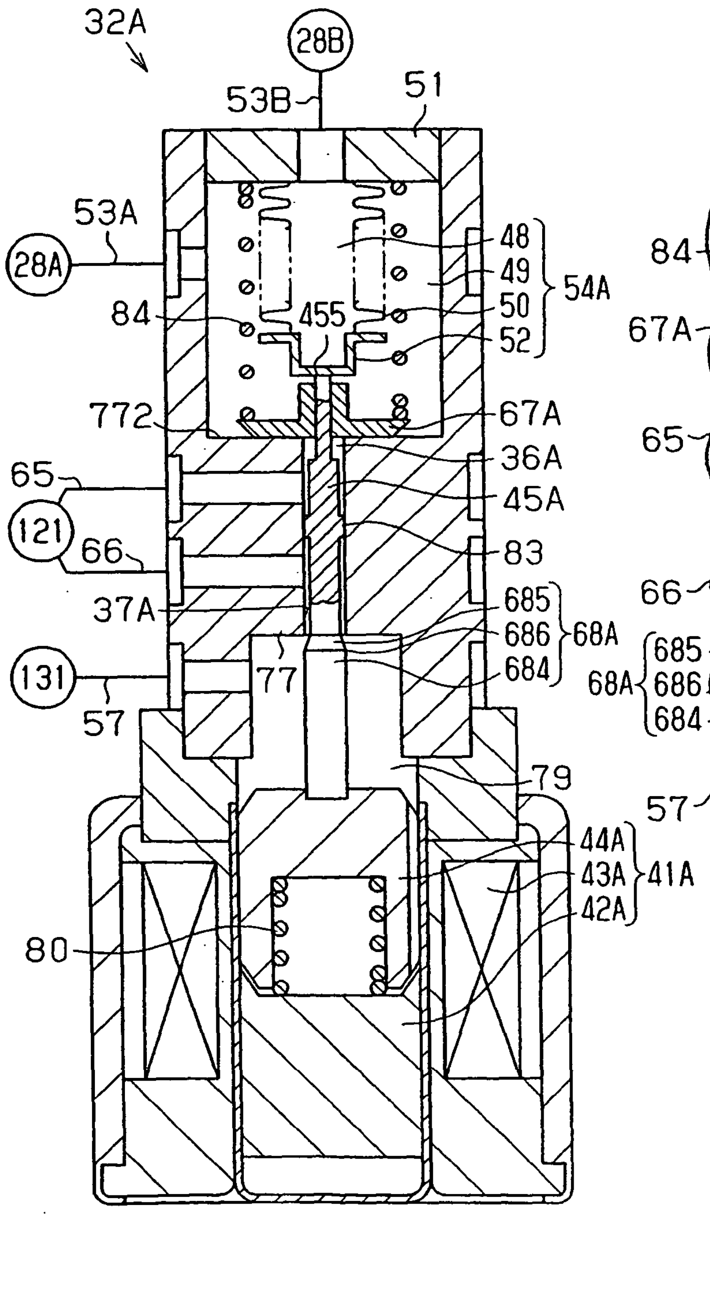
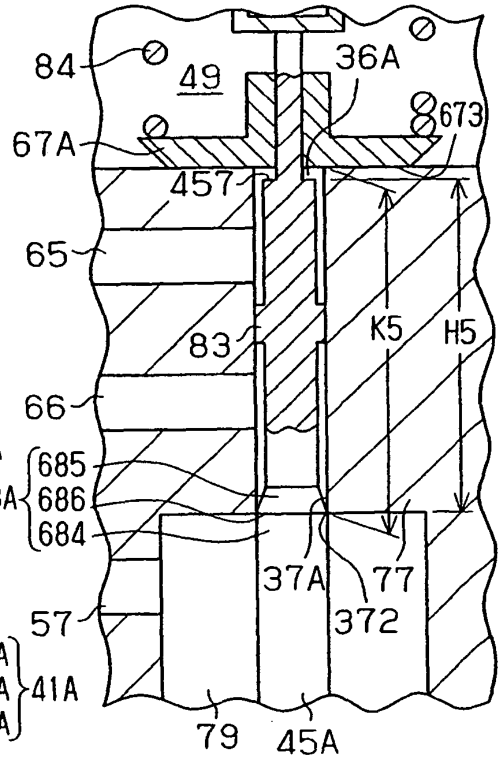


Fig.14(b)



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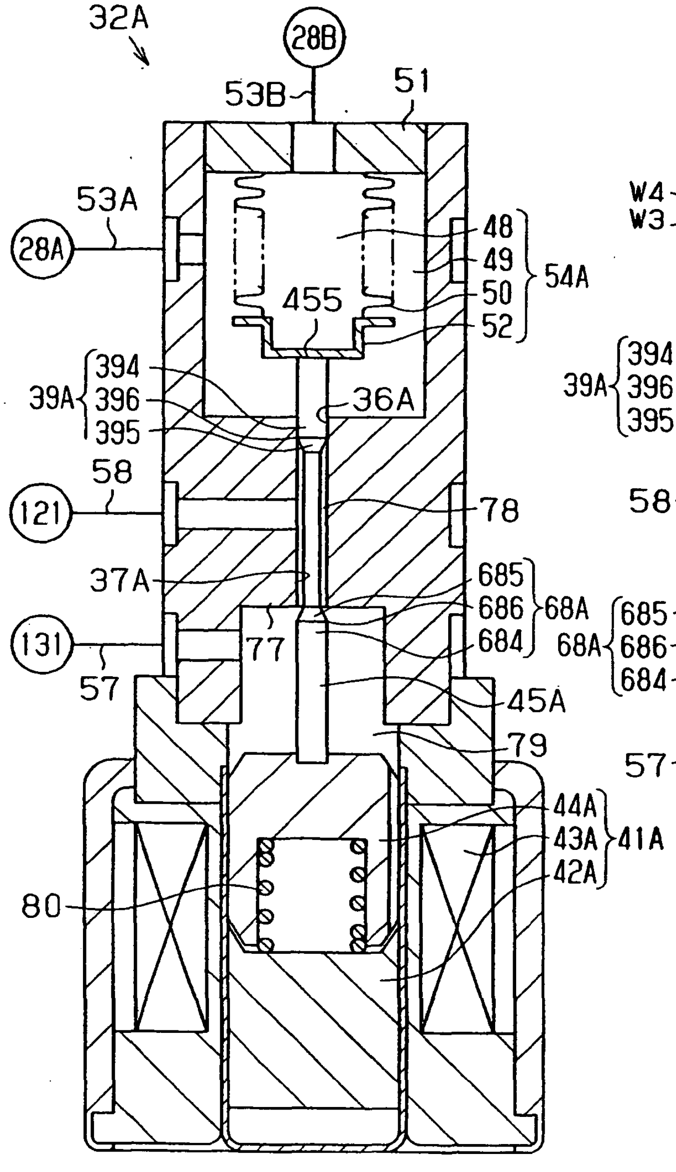
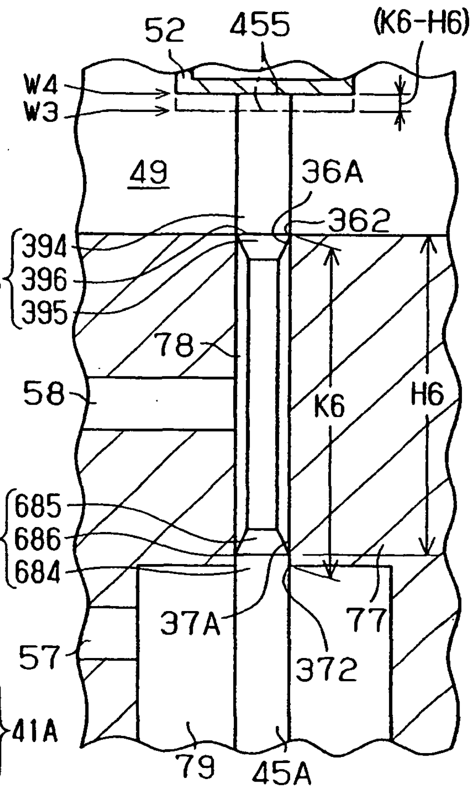


Fig.15(b)



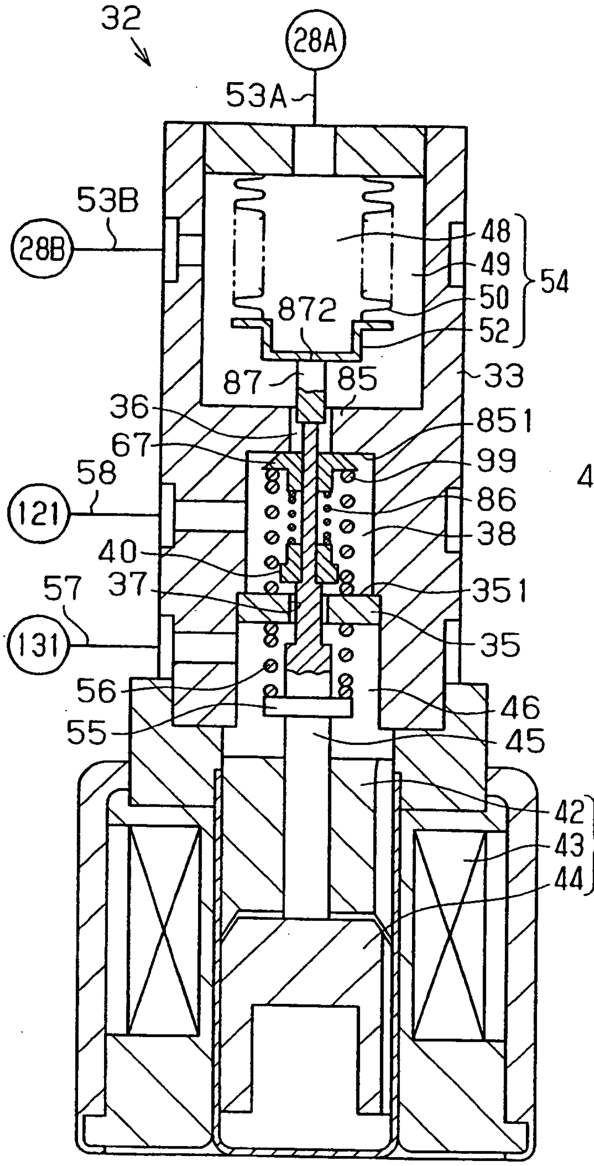


Fig.16(a)
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28A
53A
53B
28B
48
49
50
52
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872
87
85
33
36
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44

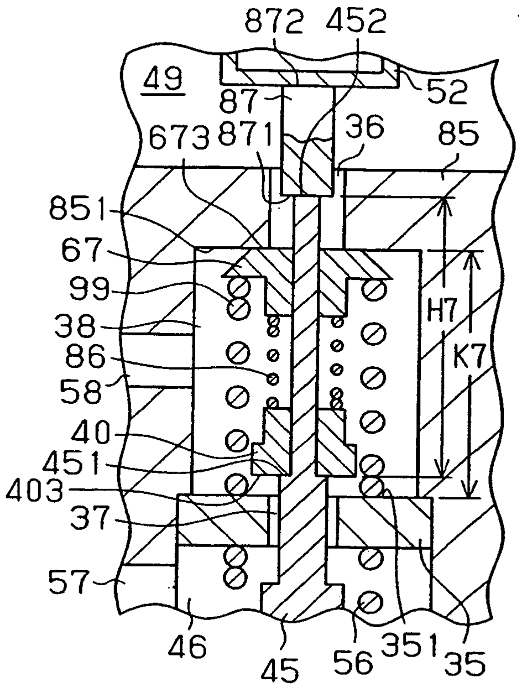
Fig.16(b)
872
452
49
52
87
673
871
36
85
851
67
99
H7
38
K7
86
58
40
451
403
37
57
46
45
56
351
35

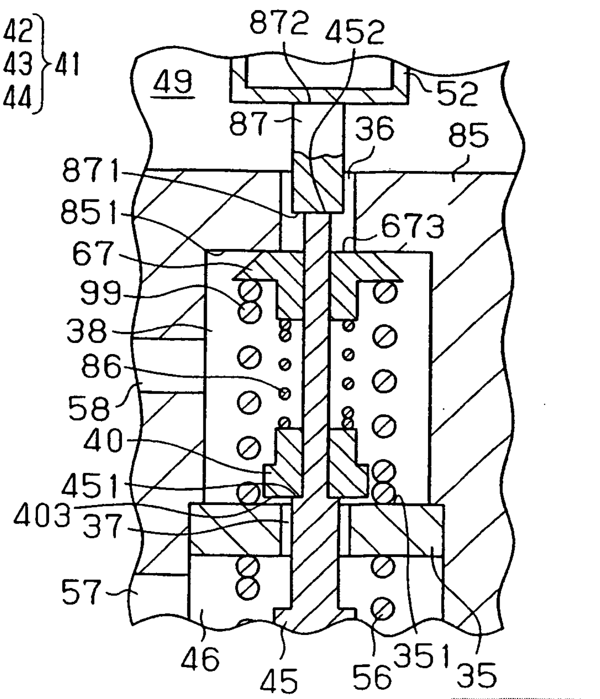
Fig.16(c)
872
452
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52
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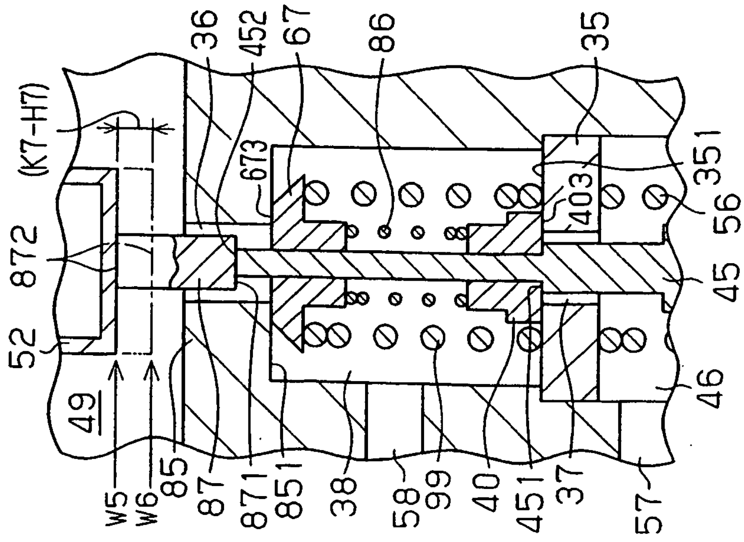
Fig.17(a)



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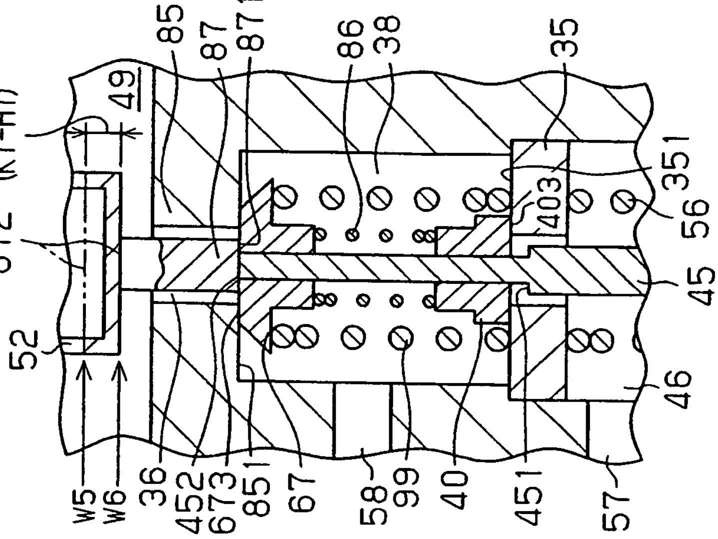

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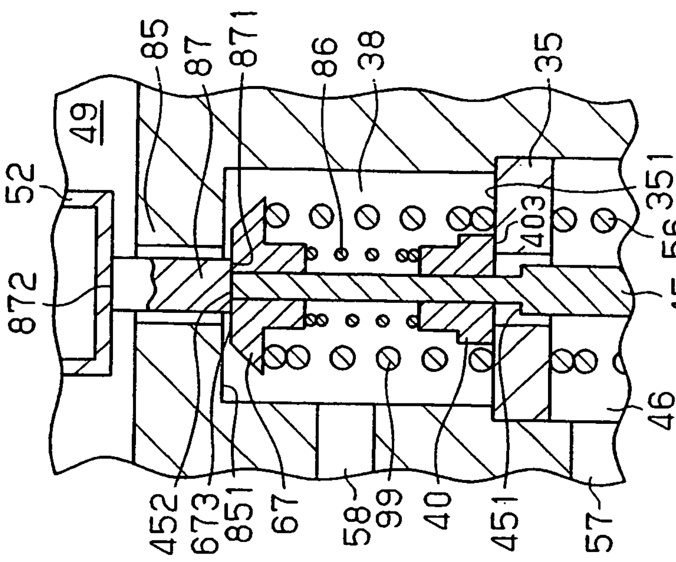

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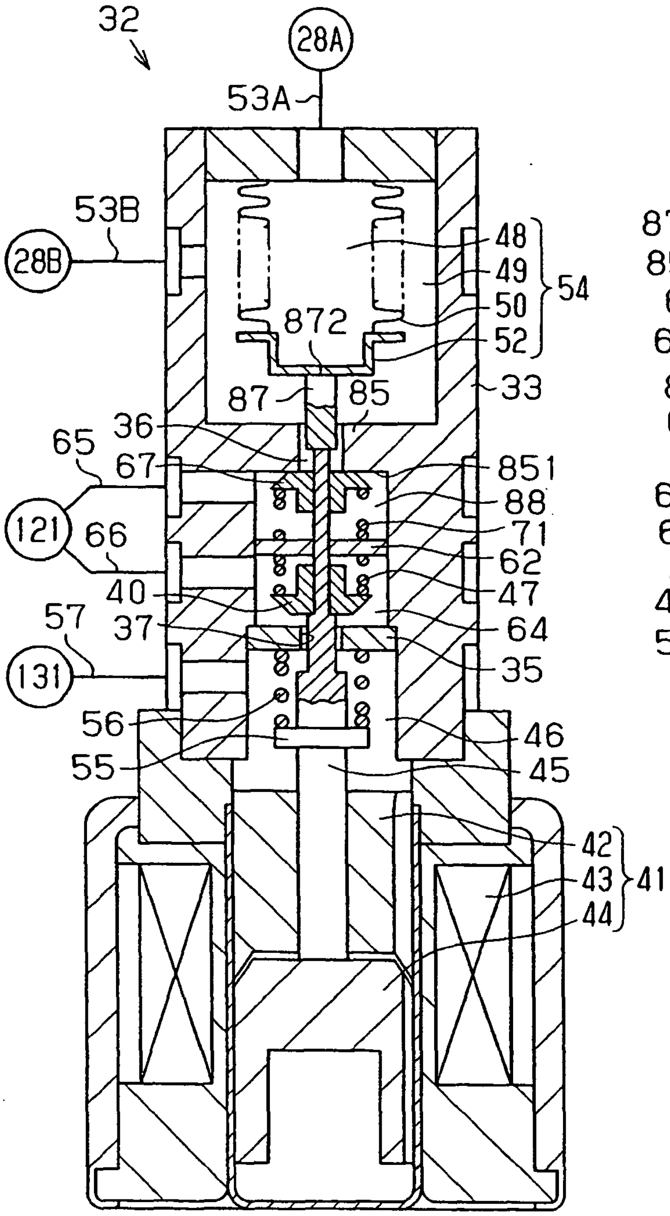


Fig.18(b)

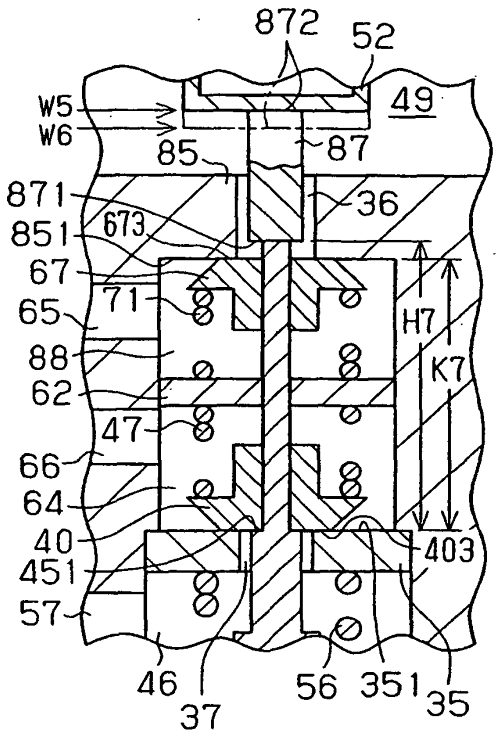


Fig.19(a)

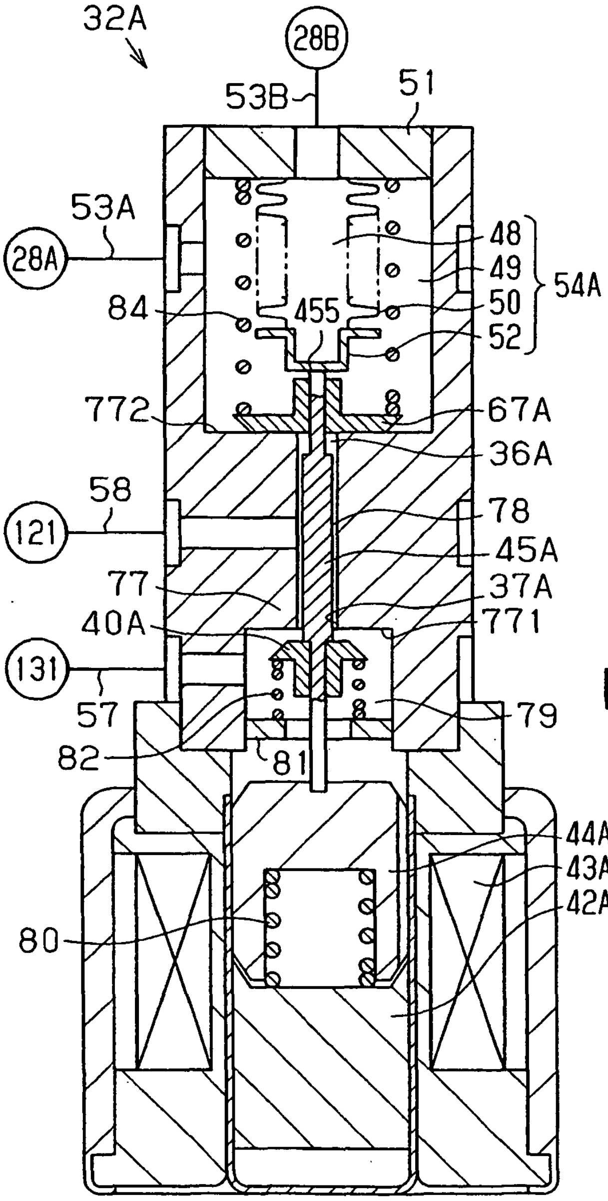
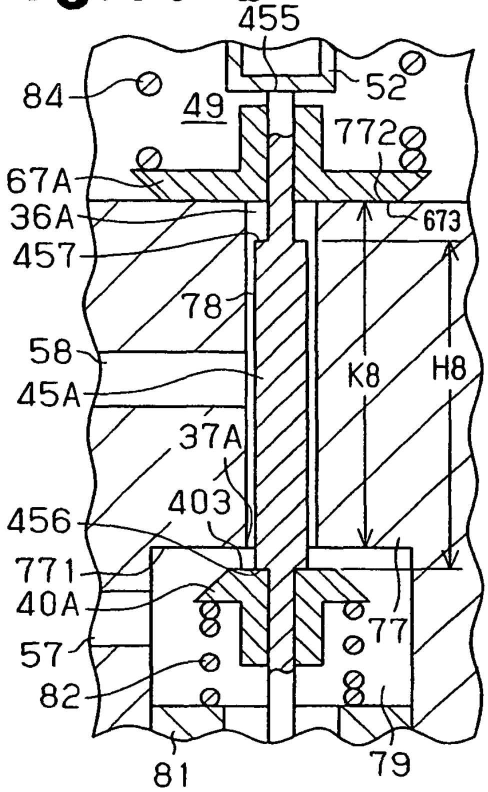


Fig.19(b)



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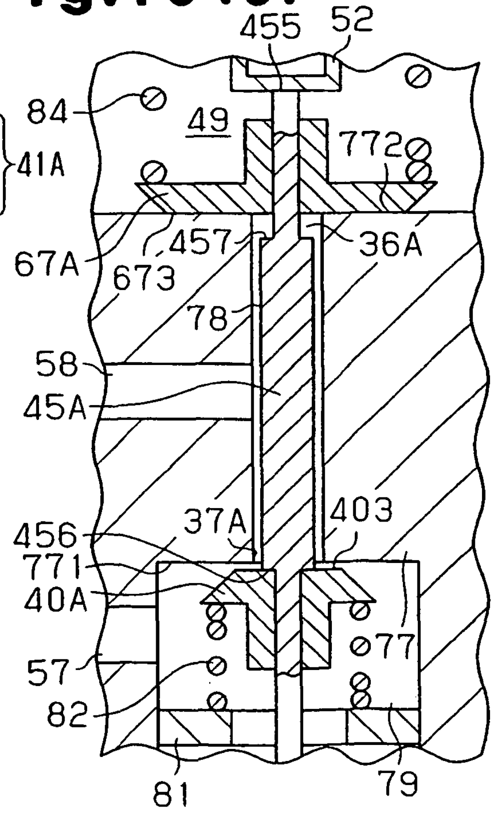


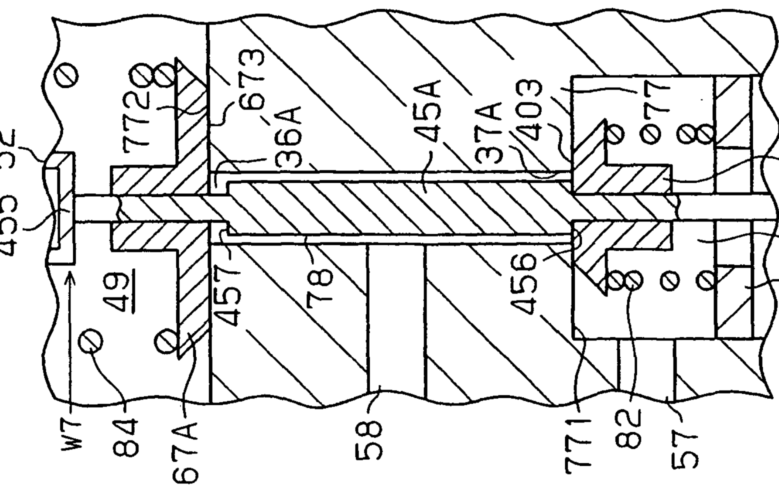


Fig.20(a)

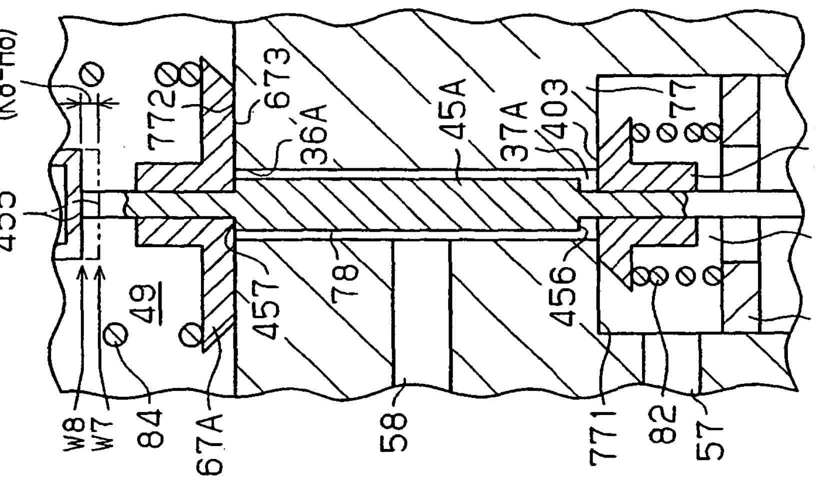


Fig.20(b)

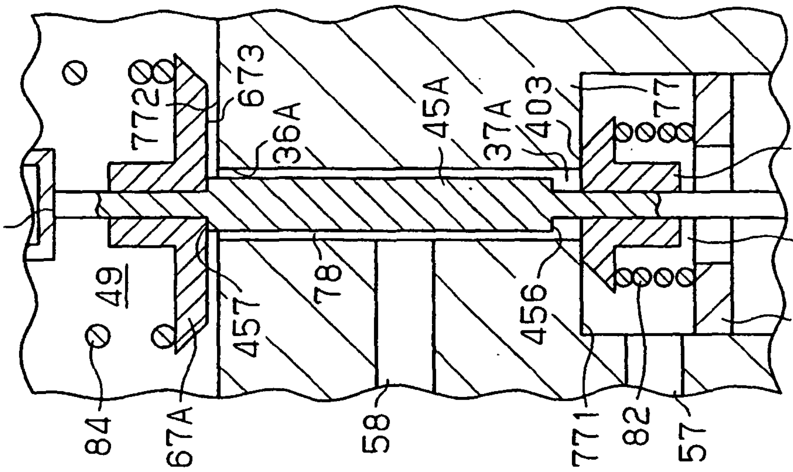
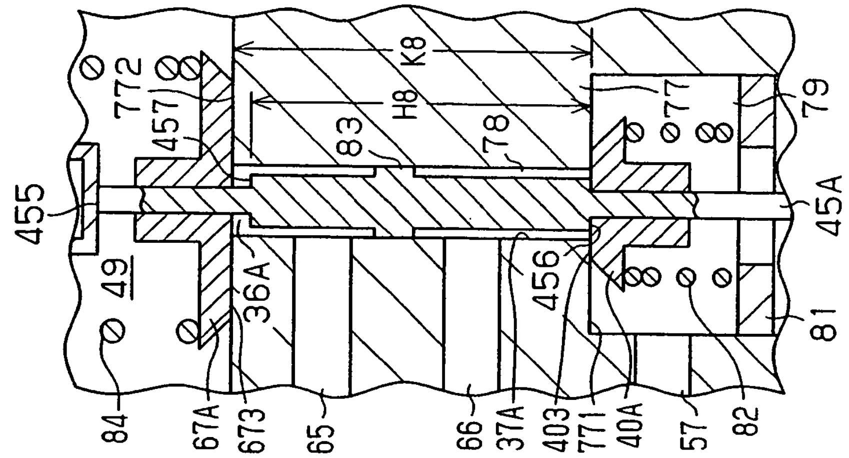


Fig.20(c)

Fig.21



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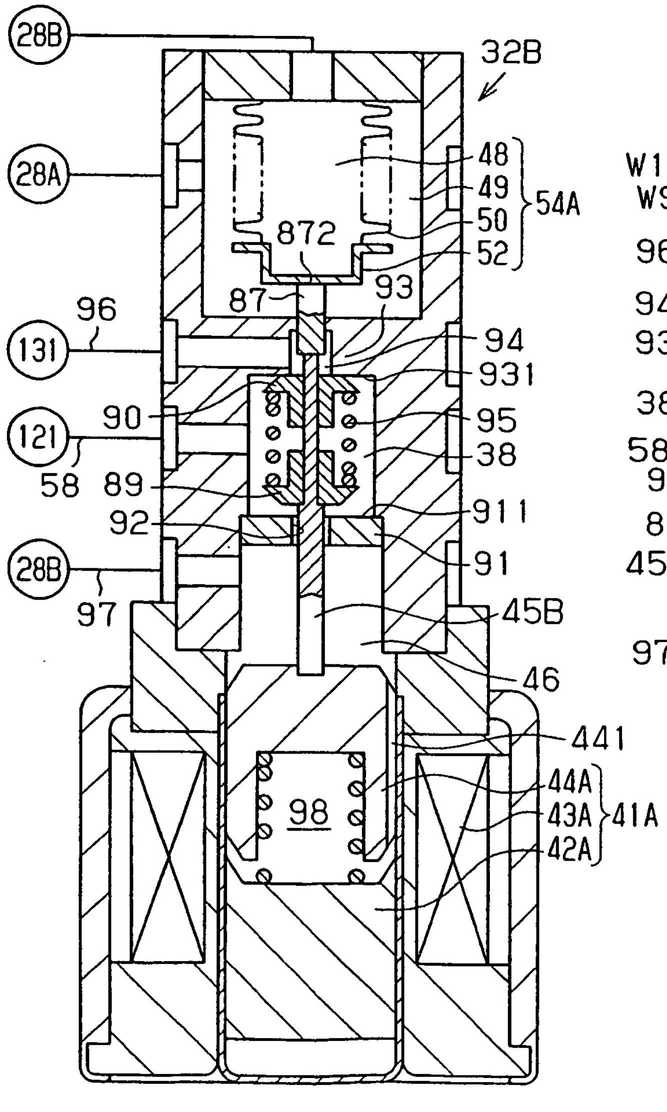


Fig.22(b)

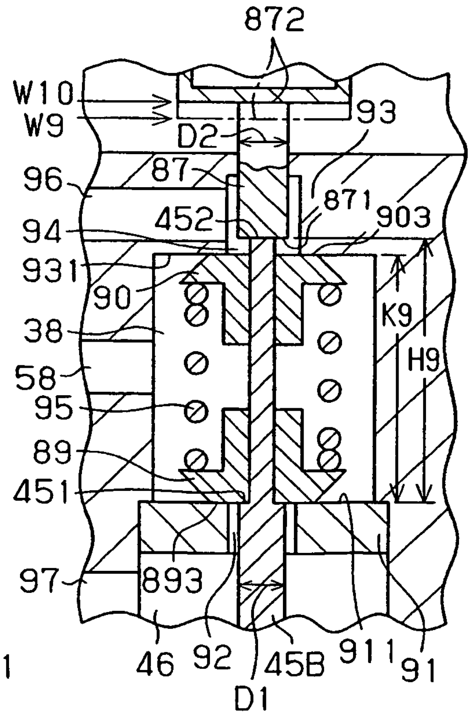
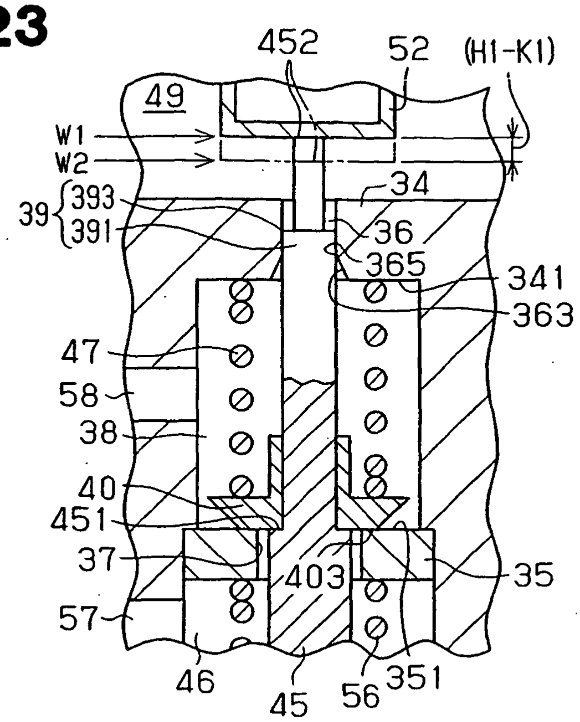


Fig.23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W1
W2
34
39
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351

Fig.24

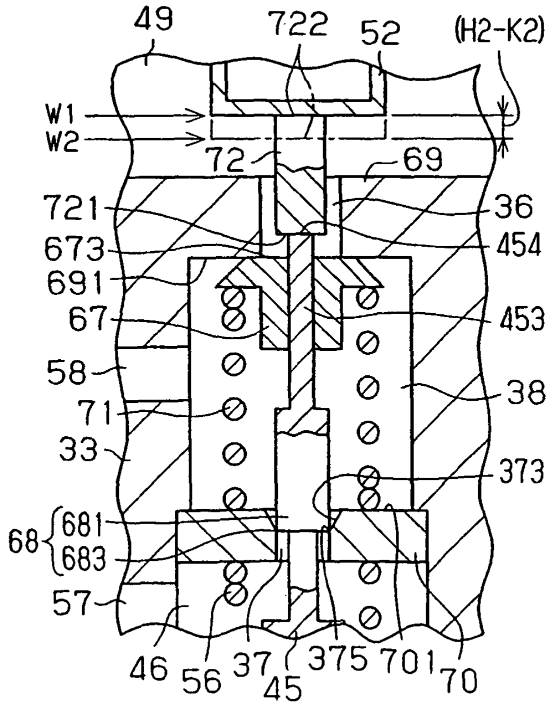
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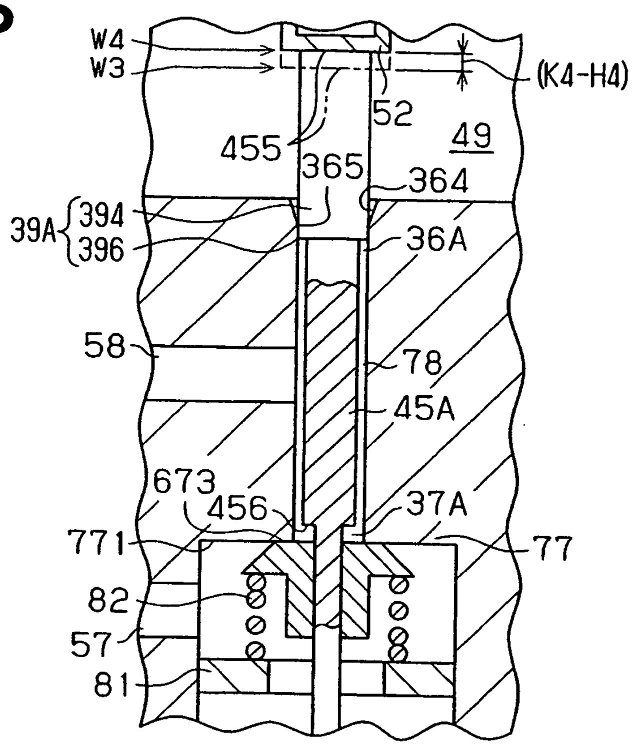
Fig.25


W4
W3
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36A
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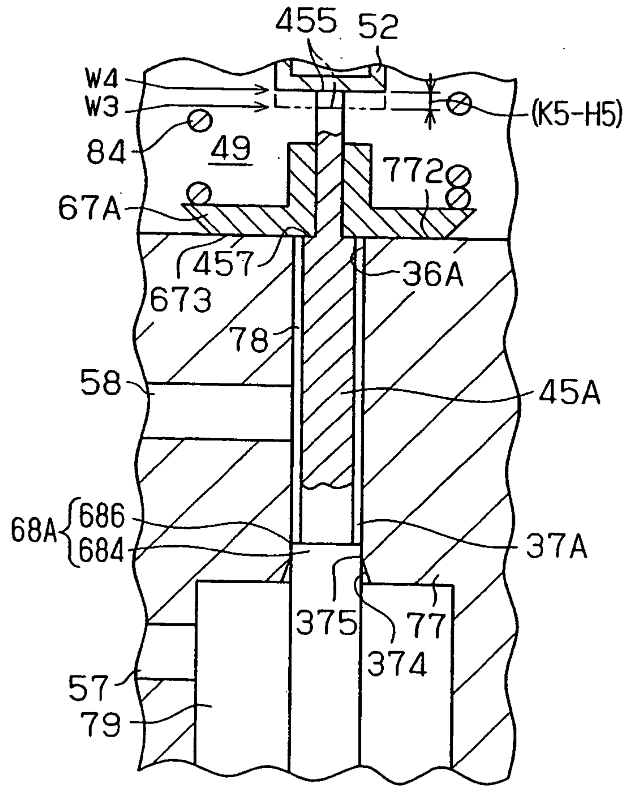
456
37A
771
77
82
57
81

Fig.26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37A
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57
79

Fig.27(a)

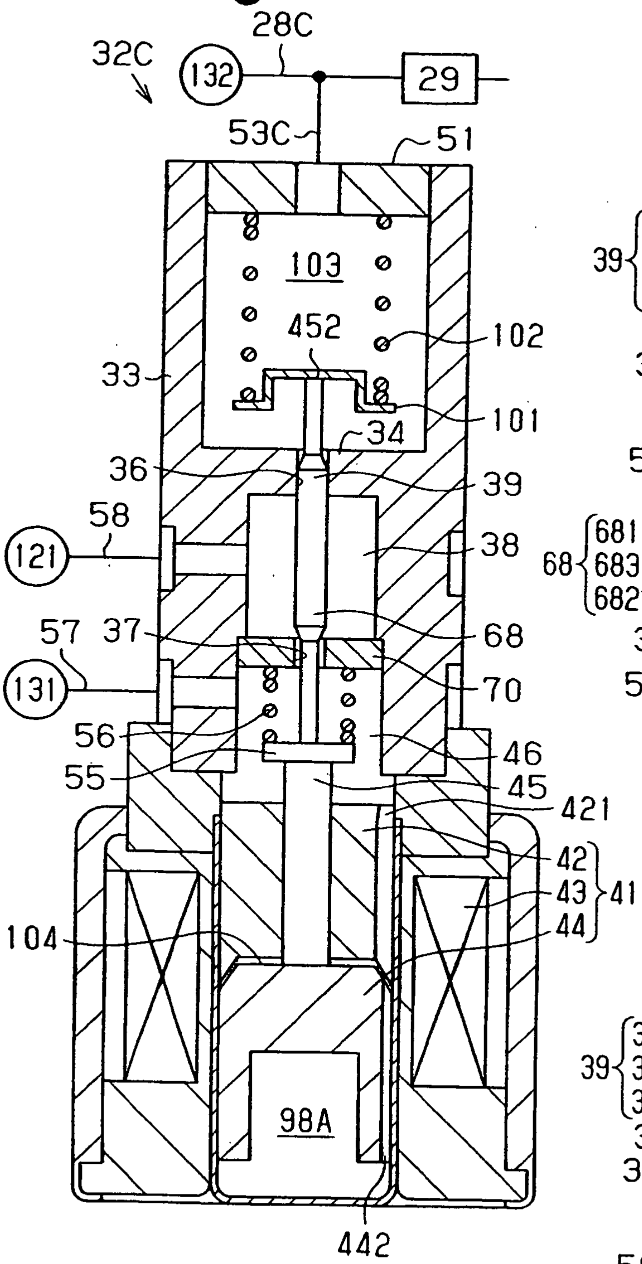


Fig.27(b)

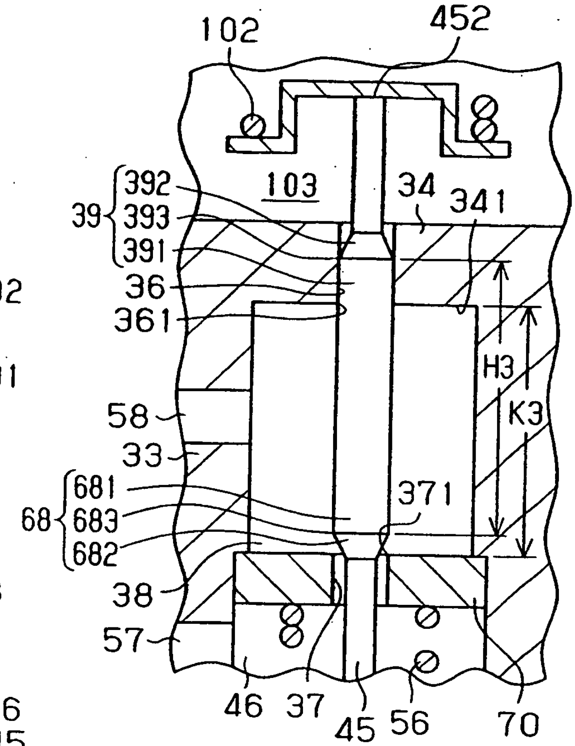
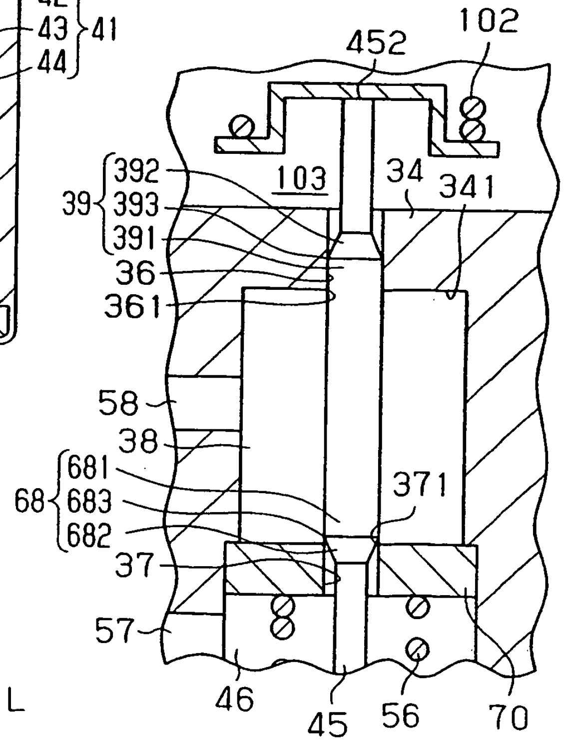


Fig.27(c)



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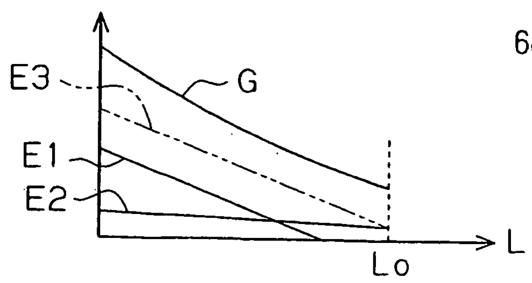


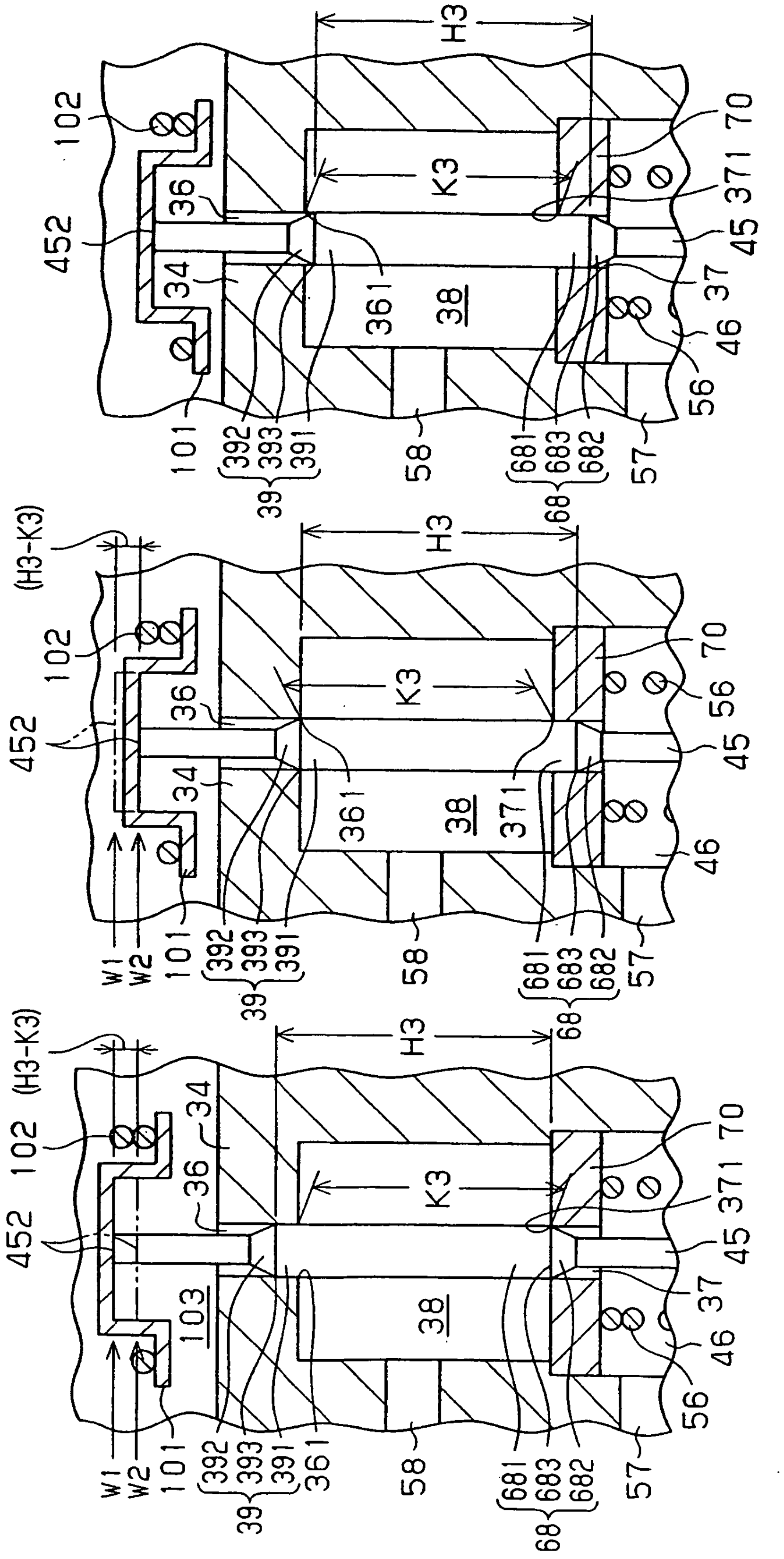


Fig.28(a)

Fig.28(b)

Fig.28(c)

Fig.29(a)

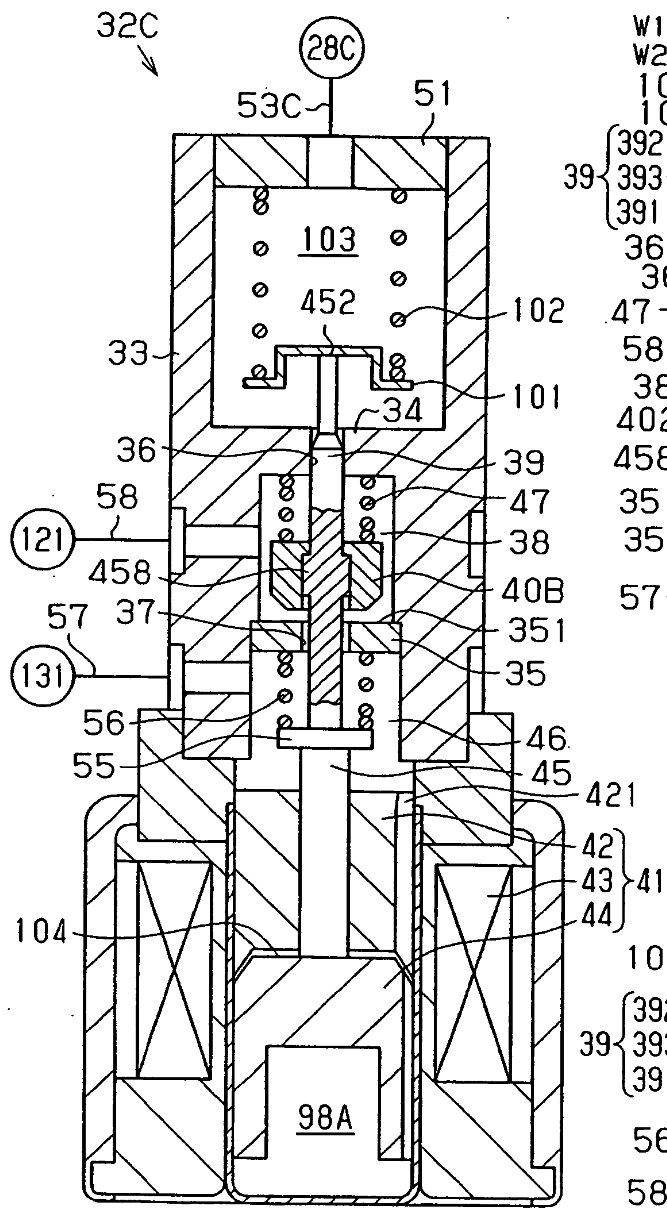


Fig.29(b)

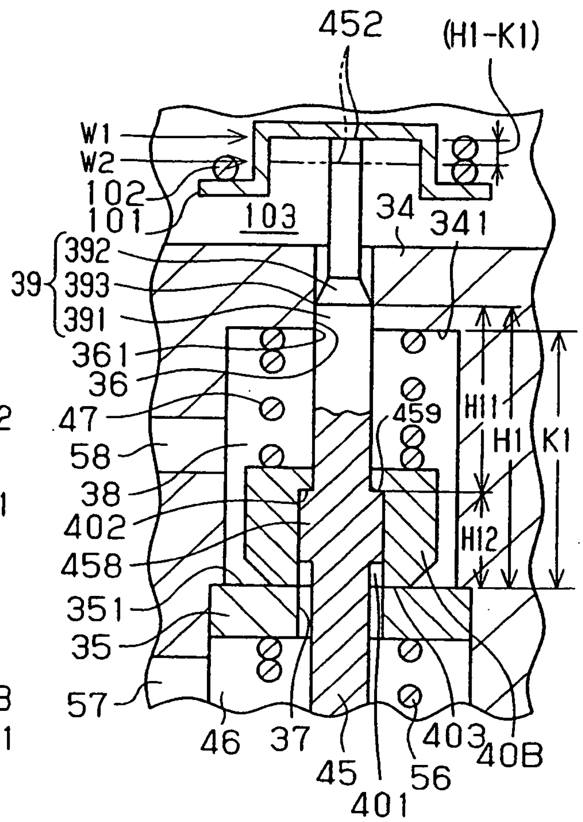
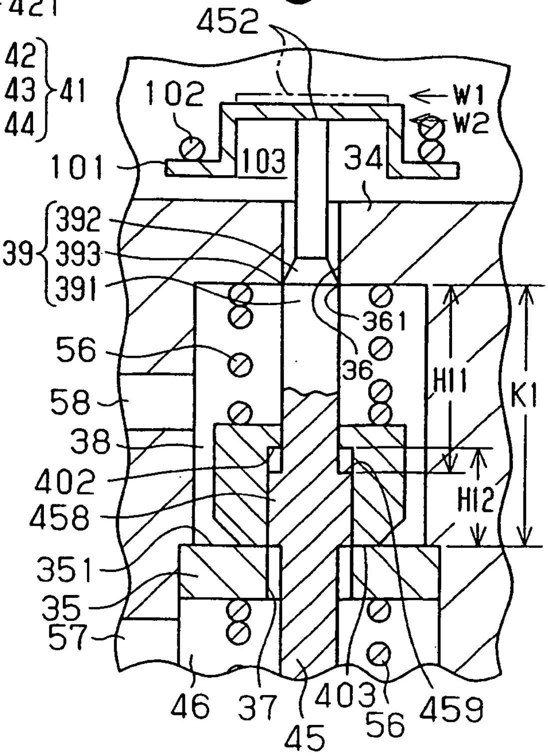


Fig.29(c)



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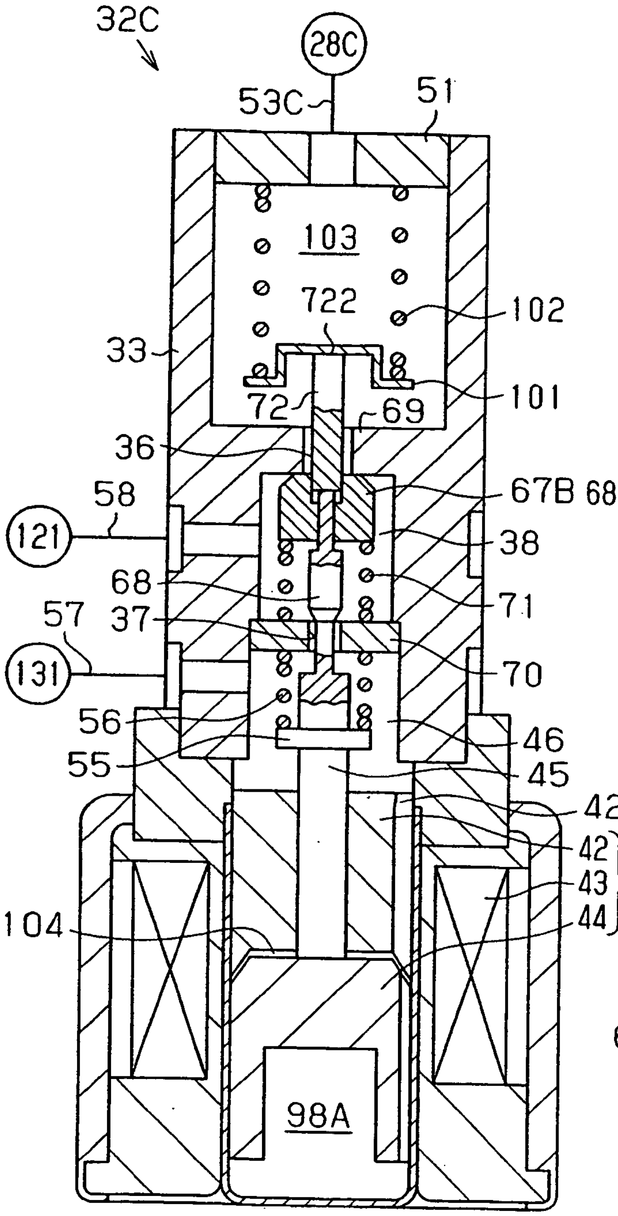


Fig.30(b)

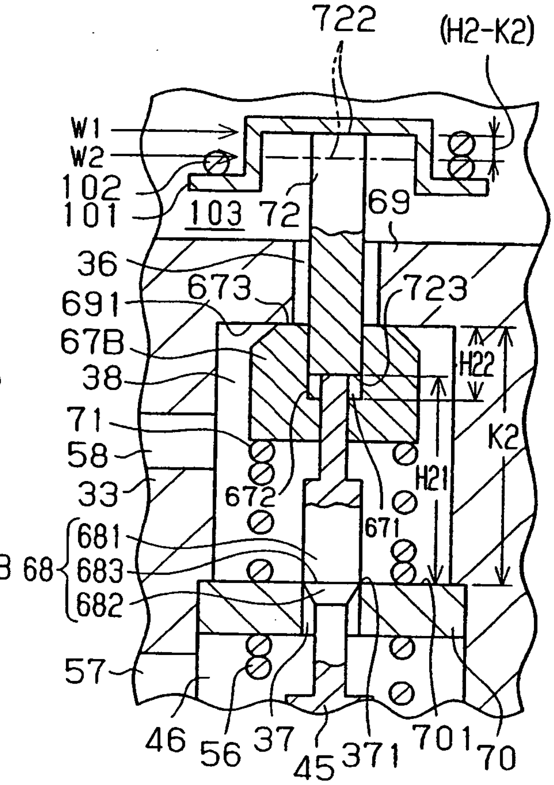


Fig.30(c)

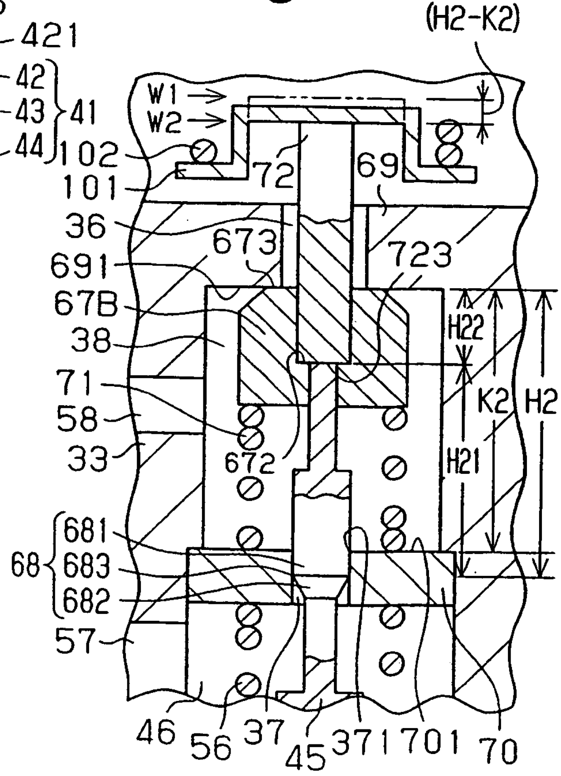


Fig.31 (a)

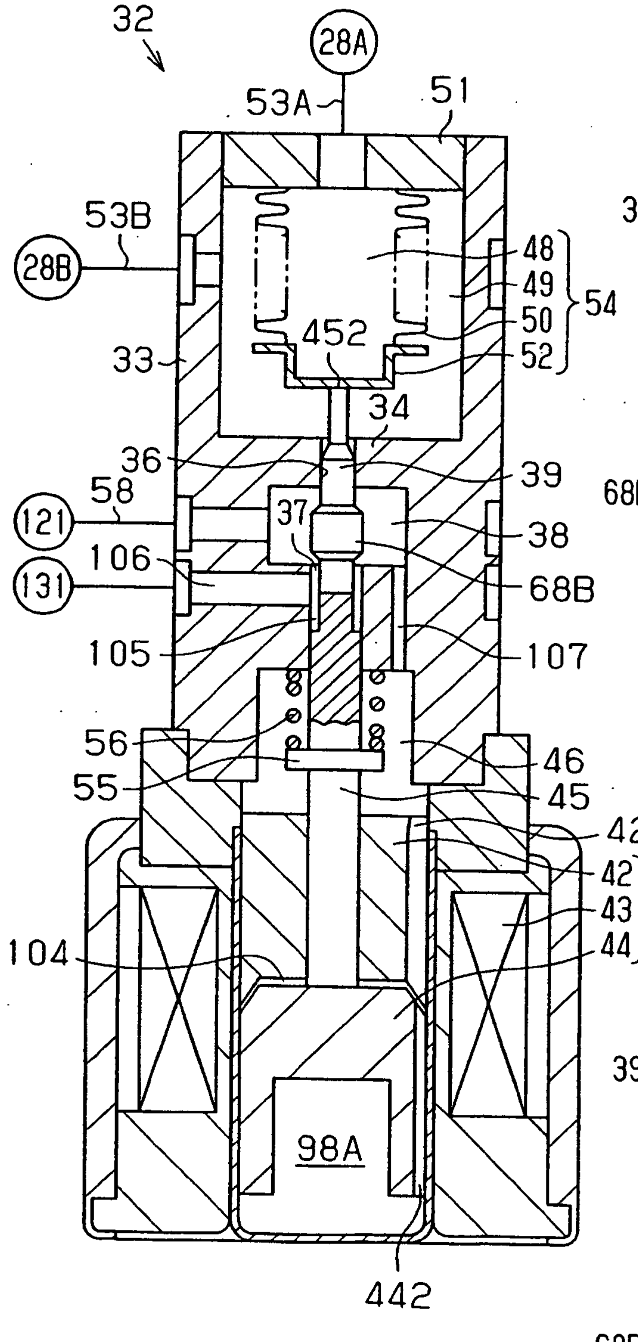


Fig.31 (b)

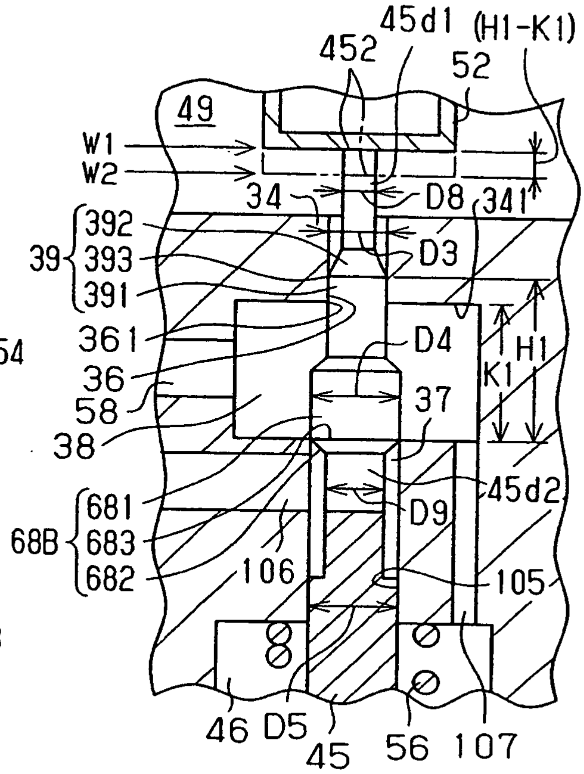


Fig.31 (c)

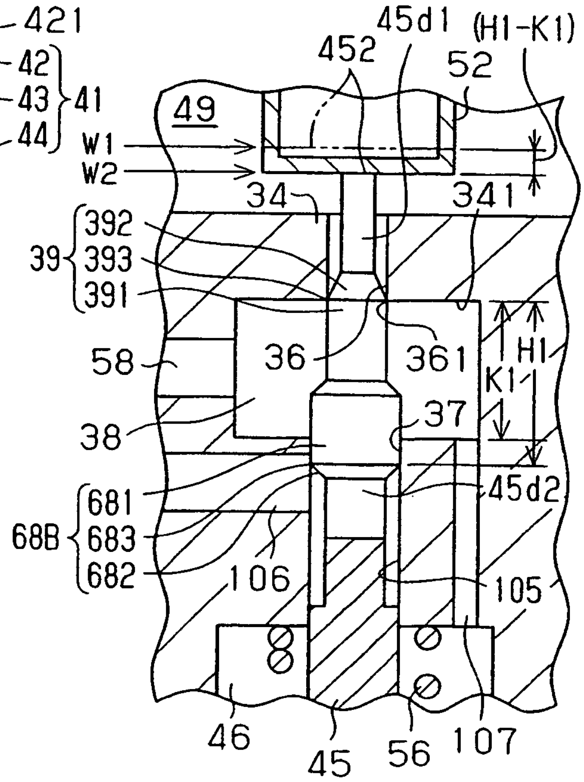


Fig.32

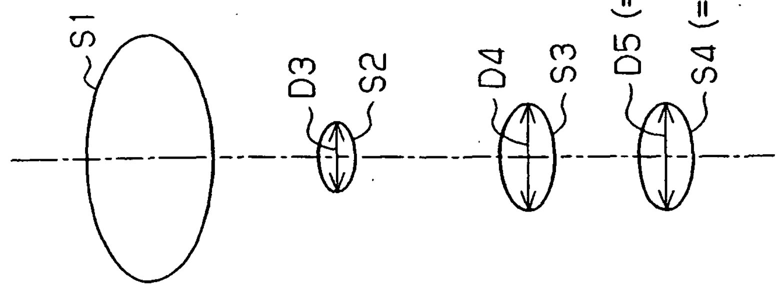


Fig.33(b)

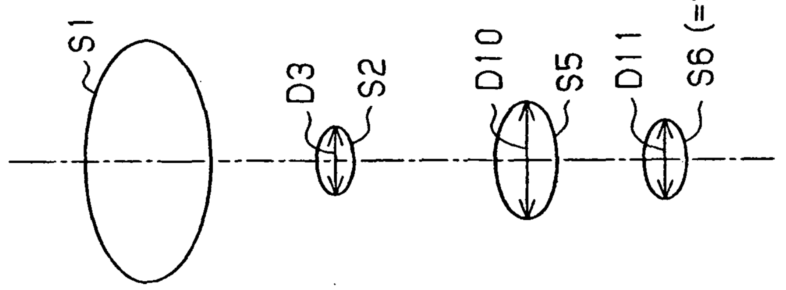
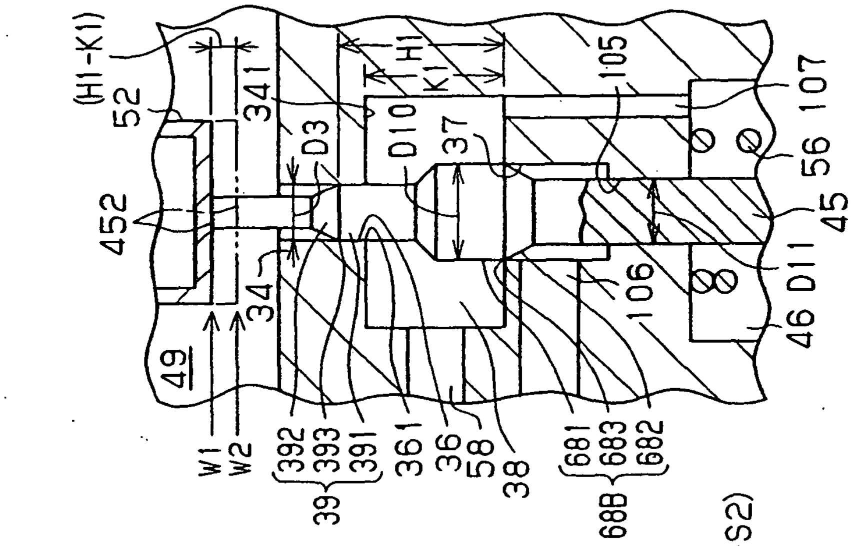


Fig.33(a)



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1081378 A **[0003]**
- JP 2000249050 A **[0004]**