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(30) Priority: **15.03.2006 JP 2006071237**(71) Applicant: **KABUSHIKI KAISHA TOYOTA****JIDOSHOKKI****Kariya-shi, Aichi 448-8671 (JP)**

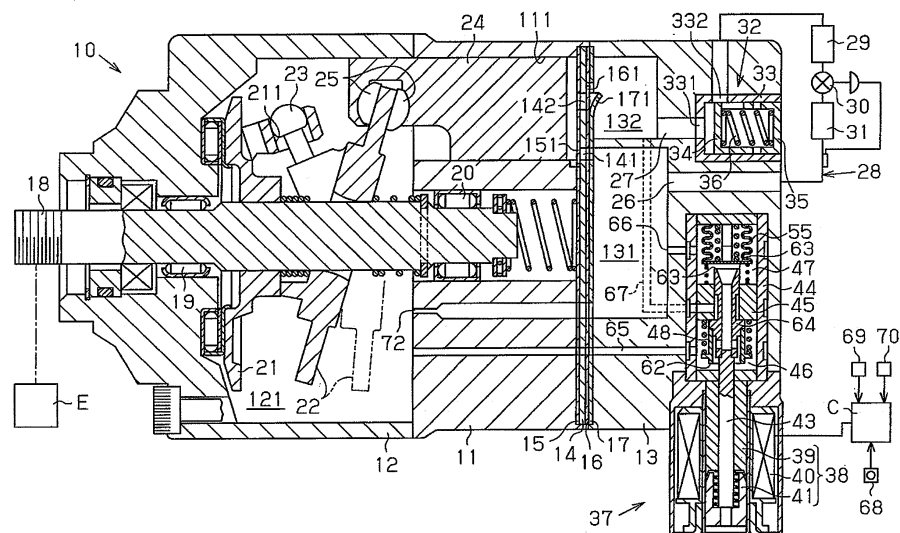
(72) Inventors:

- **Umemura, Satoshi**
Kariya-shi Aichi 448-8671 (JP)
- **Kawaguchi, Masahiro**
Kariya-shi Aichi 448-8671 (JP)
- **Ota, Masaki**
Kariya-shi Aichi 448-8671 (JP)

(74) Representative: **TBK-Patent****Bavariaring 4-6****80336 München (DE)****(54) Displacement control valve of variable displacement compressor**

(57) A displacement control valve includes an electromagnetic solenoid and a drive force transmitting body. A pressure sensing chamber communicates with a suction chamber and a pressure sensing body is located in the pressure sensing chamber. An internal passage is provided in the transmitting body and an external passage is provided about the transmitting body. The first to third valve bodies are provided at the transmitting body. The first valve body adjusts a cross-sectional area of a passage between the external passage and the internal passage. The second valve body adjusts a cross-sectional area of a passage between the internal passage

and the pressure sensing chamber. The third valve body adjusts a cross-sectional area of a passage between the external passage and a discharge chamber. The transmitting body is switched among first, second, and third arrangement states by the electromagnetic solenoid. With the transmitting body at the first arrangement state, the third valve body is at an open position when the first valve body is at a closed position. With the transmitting body at the second arrangement state, the first valve body is at an open position when the third valve body is at a closed position. With the transmitting body at the third arrangement state, both of the first and third valve bodies are at the open position.

Fig.1**EP 1 835 177 A2**

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a displacement control valve of a variable displacement compressor that controls displacement through adjustment of pressure in a pressure control chamber by supplying refrigerant from a discharge pressure zone to the control pressure chamber through a supply passage and drawing the refrigerant from the control pressure chamber to a suction pressure zone through a discharge passage.

[0002] In a variable displacement compressor having a control pressure chamber accommodating a swash plate, the inclination angle of the swash plate is controlled to become smaller as the pressure in the control pressure chamber becomes higher and become greater as the pressure in the control pressure chamber becomes lower. As the inclination angle of the swash plate becomes smaller, the stroke of pistons connected to the swash plate becomes smaller, thus decreasing the displacement. As the inclination angle of the swash plate becomes greater, the stroke of the pistons becomes greater, increasing the displacement.

[0003] Japanese Laid-Open Patent Publication No. 2003-322086 describes a displacement control valve that adjusts the flow rate of the refrigerant supplied from a discharge pressure zone to a control chamber and the flow rate of the refrigerant discharged from the control chamber to a suction pressure zone. The control chamber of this technique corresponds to a control pressure chamber described herein.

[0004] The displacement control valve described in Japanese Laid-Open Patent Publication No. 2003-322086 includes a pressure sensing device, an electromagnetic solenoid, and a valve body operated by the electromagnetic solenoid. A detection communication passage, or an open passage communicating with a suction pressure zone, is provided in the valve body. The pressure in the open passage, or suction pressure, acts on an engagement portion joined with a bellows of the pressure sensing device. A displacement chamber is defined around the bellows and communicates with the control chamber through a second communication passage. Also, the displacement chamber is connectable to a first communication passage, or a discharge pressure zone, through a valve hole selectively opened and closed by the valve body.

[0005] The bellows is extended and contracted by control pressure, or the discharge pressure, supplied through the first communication passage and the valve hole or the pressure in a control chamber supplied through a second communication passage. In this displacement control valve, suction pressure of refrigerant flowing from the detection communication passage and the control pressure of the refrigerant flowing from the first communication passage, or the discharge pressure, act on the valve body to control the pressure in the control chamber.

[0006] In the displacement control valve described in Japanese Laid-Open Patent Publication No. 2003-322086, a passage for drawing the refrigerant from the control chamber to the detection communication passage, or the suction pressure zone, is not provided. This makes it necessary to define a discharge passage that discharges the refrigerant from the control chamber to the suction pressure zone provided externally from the displacement control valve.

[0007] The refrigerant is supplied to the control chamber in a compressed and high-pressure state. Therefore, as the amount of the refrigerant drawing from the control chamber to the suction pressure zone becomes greater, the operation efficiency of the variable displacement compressor becomes lower. Accordingly, to improve the operation efficiency of the variable displacement compressor, it is desired that the drawing passage that discharges the refrigerant from the control chamber to the suction pressure zone should have a minimum cross-sectional area.

[0008] If the variable displacement compressor is held in a deactivated state for a long time, the refrigerant liquefies and accumulates in the control chamber, or a control pressure chamber. If the variable displacement compressor has a discharge passage with a small cross-sectional area provided externally from the displacement control valve and is activated in the state that the refrigerant liquefies and accumulates in the control chamber, the refrigerant retained in the control chamber in the liquefied state cannot be rapidly drawn to the suction pressure zone. The liquefied refrigerant in the control pressure chamber thus evaporates and excessively increases the pressure in the control pressure chamber. As a result, excessive time is consumed for sufficiently raising the displacement after the compressor is started.

[0009] Contrastingly, if the drawing passage external from the displacement control valve has an excessively great cross-sectional area, the flow rate of the refrigerant discharged from the control chamber to the suction pressure zone becomes excessively great. This lowers the operation efficiency of the variable displacement compressor in controlling of the displacement.

SUMMARY OF THE INVENTION

[0010] Accordingly, it is an objective of the present invention to provide a displacement control valve that shortens the time spent for sufficiently increasing the displacement immediately after starting of a variable displacement compressor and adjusts the discharge flow rate of refrigerant to a level suitable for improving operation efficiency of the compressor.

[0011] To achieve the foregoing objective and in accordance with one aspect of the present invention, a displacement control valve of a variable displacement compressor is provided. The compressor draws refrigerant from a suction pressure zone and discharges the refrigerant to a discharge pressure zone, and controls dis-

placement according to a pressure in a control pressure chamber. The displacement control valve includes an electromagnetic solenoid, a drive force transmitting body, a pressure sensing portion, an internal passage, an external passage, and first, second, and third valve bodies. The drive force transmitting body is movable along a movement axis, and receives, from the electromagnetic solenoid, a drive force in a drive direction along the movement axis. The pressure sensing portion has a pressure sensing chamber that communicates with the suction pressure zone and a pressure sensing body that receives a pressure in the pressure sensing chamber. The pressure sensing body is urged in the drive direction by the pressure in the pressure sensing chamber. The position of the pressure sensing body in a direction along the movement axis is regulated in accordance with the pressure in the pressure sensing chamber. The internal passage is provided in the drive force transmitting body to be connectable to the pressure sensing chamber. The external passage is provided about the drive force transmitting body to be connected to the control pressure chamber. The first valve body is provided at the drive force transmitting body, and adjusts a cross-sectional area of a passage between the external passage and the internal passage. The second valve body is contactable with and separable from the pressure sensing body. The second valve body adjusts a cross-sectional area of a passage between the internal passage and the pressure sensing chamber. The third valve body is provided at the drive force transmitting body, and adjusts a cross-sectional area of a passage between the external passage and the discharge pressure zone. The drive force transmitting body is switched among first, second, and third arrangement states by the electromagnetic solenoid. With the drive force transmitting body at the first arrangement state, the third valve body is at an open position when the first valve body is at a closed position. With the drive force transmitting body at the second arrangement state, the first valve body is at an open position when the third valve body is at a closed position. With the drive force transmitting body at the third arrangement state, both of the first and third valve bodies are at the open position.

[0012] In accordance with another aspect of the present invention, a variable displacement compressor is provided. The variable displacement compressor has the displacement control valve described above and a bleed passage. The bleed passage connects the control pressure chamber and the suction pressure zone to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a cross-sectional side view showing a variable displacement compressor having a displacement control valve according to one embodiment of

the present invention;

Fig. 2 is a cross-sectional view showing the displacement control valve of Fig. 1;

Fig. 3 is an enlarged cross-sectional view showing a portion of the displacement control valve of Fig. 2; Fig. 4 is an enlarged cross-sectional view showing a portion of the displacement control valve of Fig. 2; and

Fig. 5 is a cross-sectional view showing a displacement control valve according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] An embodiment of the present invention will now be described with reference to Figs. 1 to 4.

[0015] As shown in Fig. 1, a front housing member 12 is joined with the front end of a cylinder block 11. A rear housing member 13 is joined with the rear end of the cylinder block 11 through a valve plate 14, valve flap plates 15, 16, and a retainer plate 17. The cylinder block 11, the front housing member 12, and the rear housing member 13 form the housing of a clutchless type variable displacement compressor 10.

[0016] A control pressure chamber 121 is defined by the front housing member 12 and the cylinder block 11. A rotary shaft 18 is supported by the front housing member 12 and the cylinder block 11 through radial bearings 19, 20 in such a manner that the rotary shaft 18 rotates about the axis of the rotary shaft 18. The rotary shaft 18 projects from the control pressure chamber 121 to the exterior and rotates when driven by a vehicle engine E, which is an external drive source.

[0017] A rotation support 21 is secured to the rotary shaft 18 and a swash plate 22 is supported by the rotary shaft 18. In this state, the swash plate 22 is allowed to move and incline along the axial direction of the rotary shaft 18. A couple of guide pins 23, which are fixed to the swash plate 22, are provided in the swash plate 22. The guide pins 23 are movably received in guide bores 211, which are defined in the rotation support 21.

[0018] The swash plate 22 is allowed to incline with respect to the axis of the rotary shaft 18 and rotate integrally with the rotary shaft 18 through cooperation of the guide bores 211 and the guide pins 23. The swash plate 22 is tilted by the sliding of the guide pins 23 in the guide bores 211 and the sliding of the swash plate 22 on the rotary shaft 18.

[0019] Specifically, as the radial center of the swash plate 22 moves toward the rotation support 21 along the axis of the rotary shaft 18, the inclination angle of the swash plate 22 increases. When the rotation support 21 and the swash plate 22 contact each other, the inclination angle of the swash plate 22 is at a maximum inclination position. In the state of the swash plate 22 indicated by the solid lines of Fig. 1, the swash plate 22 is inclined at a maximum inclination angle. In the state of the swash

plate 22 indicated by the chain lines of Fig. 1, the swash plate 22 is inclined at a minimum inclination angle. The minimum inclination angle of the swash plate 22 is set to a value slightly greater than zero degrees.

[0020] A plurality of cylinder bores 111 are defined in the cylinder block 11. Each bore 111 receives one of a plurality of pistons 24. Rotation of the swash plate 22 is converted to reciprocation of each of the pistons 24 in the axial direction of the rotary shaft 18 through a shoe 25. The pistons 24 reciprocate in the corresponding cylinder bores 111.

[0021] A suction chamber 131 and a discharge chamber 132 are defined in the rear housing member 13. The control pressure chamber 121 communicates with the suction chamber 131 through a bleed passage 72. Suction ports 141 extend through the valve plate 14, the valve flap plate 16, and the retainer plate 17. Discharge ports 142 extend through the valve plate 14 and the valve flap plate 15. Suction valve flaps 151 are formed in the valve flap plate 15 and discharge valve flaps 161 are formed in the valve flap plate 16. When each piston 24 moves from the top dead center to the bottom dead center (moves from the right to the left as viewed in Fig. 1), the refrigerant flows from the suction chamber 131, or a suction pressure zone, to the cylinder bore 111 through the suction port 141 while flexing the suction valve flap 151. When the piston 24 moves from the bottom dead center to the top dead center (moves from the left to the right as viewed in Fig. 1), the gaseous refrigerant is discharged from the cylinder bore 111 to the discharge chamber 132, or a discharge pressure zone, through the discharge port 142 while flexing the discharge valve flap 161. The opening degree of the discharge valve flap 161 is regulated through contact between the discharge valve flap 161 and a retainer 171 provided on the retainer plate 17.

[0022] A suction passage 26 that introduces the refrigerant into the suction chamber 131 and a discharge passage 27 that discharges the refrigerant from the discharge chamber 132 are connected together by an external refrigerant circuit 28. The external refrigerant circuit 28 includes a heat exchanger 29 that radiates heat from the refrigerant, an expansion valve 30, and a heat exchanger 31 that transmits the ambient heat to the refrigerant. The expansion valve 30 controls the flow rate of the refrigerant supplied to the heat exchanger 31 in correspondence with variation of the temperature of the refrigerant at an outlet of the heat exchanger 31.

[0023] A check valve 32 is provided in the discharge passage 27. The check valve 32 has a cylindrical valve housing 33, a cylindrical valve body 34, a cylindrical spring seat 35, and a compression spring 36. The valve body 34 is slidably received in the valve housing 33. The spring seat 35 is fixed in the valve housing 33. The compression spring 36 is arranged between the spring seat 35 and the valve body 34. A valve hole 331 is defined in an end wall of the valve housing 33. The valve body 34 is movable between a seated position and an open position. When located at the seated position, the valve

body 34 contacts the end wall of the valve housing 33 and closes the valve hole 331. When located at the open position, the valve body 34 is separated from the end wall of the valve housing 33 and opens the valve hole 331. The compression spring 36 urges the valve body 34 toward the seated position at which the valve hole 331 is closed.

[0024] An outlet port 332 is defined in the circumferential wall of the valve housing 33. When the valve body 34 is located at the open position, the refrigerant flows from the discharge chamber 132 to the external refrigerant circuit 28 through the valve hole 331 and the outlet port 332. When the valve body 34 is at the seated position, the valve hole 331 is closed, thus preventing the refrigerant from flowing from the discharge chamber 132 to the external refrigerant circuit 28.

[0025] An electromagnetic type displacement control valve 37 is incorporated in the rear housing member 13.

[0026] As illustrated in Fig. 2, a fixed iron core 39 of an electromagnetic solenoid 38 of the displacement control valve 37 attracts a movable iron core 41 in correspondence with excitement by a current supply to a coil 40. An urging spring 42 is provided between the fixed iron core 39 and the movable iron core 41. The movable iron core 41 is urged by the urging force of the urging spring 42 to separate from the fixed iron core 39. The electromagnetic solenoid 38 is subjected to current supply control (in the illustrated embodiment, duty ratio control) by a control computer C (shown in Fig. 1). A drive rod 43 is secured to the movable iron core 41.

[0027] A partition wall 45 is fixed to a cylindrical housing 44 of the displacement control valve 37. The partition wall 45 divides the interior of the housing 44 to a chamber 46 and a pressure sensing chamber 47. A valve assembly 48 is provided in the chamber 46. A pressure sensing mechanism 49 is arranged in the pressure sensing chamber 47. The chamber 46 communicates with the control pressure chamber 121 through a passage 65. The pressure sensing chamber 47 communicates with the suction chamber 131 through a passage 66.

[0028] A valve seat plate 54 is fixed in the housing 44 to close the chamber 46. A distal portion of the drive rod 43 extends through the valve seat plate 54 and projects into the chamber 46. Further, a lid 59 is fixed in the housing 44 to close the pressure sensing chamber 47.

[0029] The valve assembly 48 has a shaft body 50 extending through the partition wall 45 and a cylindrical body 51 fixed to the shaft body 50 in the chamber 46. A shaft passage 501 is defined in the shaft body 50 and extends in the movement direction of the drive rod 43. The distal portion of the drive rod 43 is secured to the shaft body 50 and extends along the shaft passage 501. The drive rod 43 and the valve assembly 48 form a drive force transmitting body 61, which is driven by the electromagnetic force generated by the electromagnetic solenoid 38. The direction in which the drive force transmitting body 61 is driven, that is, the direction in which the drive force transmitting body 61 is urged or moved by

electromagnetic force of the electromagnetic solenoid 38, will hereafter be referred to as a drive direction of the drive force transmitting body 61. The drive direction is directed from the chamber 46 toward the pressure sensing chamber 47. In other words, the drive direction agrees with the direction of drive force that is applied to the electromagnetic solenoid 38 by the drive force transmitting body 61. The drive force transmitting body 61 is movable along a movement axis in the drive direction and a direction opposite to the drive direction.

[0030] A valve hole 52 is defined in the partition wall 45 and extends in the movement direction of the drive rod 43. The shaft body 50 is received in the valve hole 52 movably along the movement direction of the drive rod 43. A distal portion of the shaft body 50 projects into the pressure sensing chamber 47, thus allowing communication between the shaft passage 501 and the pressure sensing chamber 47.

[0031] A communication port 502 is defined in the circumferential surface of the shaft body 50 in the cylindrical body 51 and communicates with the shaft passage 501. The shaft passage 501 communicates with the interior of the cylindrical body 51 through the communication port 502. The shaft passage 501 and the communication port 502 form an internal passage that is defined in the drive force transmitting body 61 in such a manner as to communicate with the pressure sensing chamber 47. The chamber 46 is an external passage provided externally from the drive force transmitting body 61 in such a manner as to communicate with the control pressure chamber 121.

[0032] The cylindrical body 51, which is fixed to the shaft body 50, is urged by the urging force of the urging spring 53 in a direction opposite to the acting direction of the electromagnetic force produced by the electromagnetic solenoid 38. A valve body 62 capable of contacting and separating from a seat surface 541 of the valve seat plate 54 is provided at an end of the cylindrical body 51 corresponding to the electromagnetic solenoid 38. In the following, the valve body 62 will be referred to as a first valve body 62. When the first valve body 62 is located at an open position separate from the seat surface 541, the shaft passage 501 and the chamber 46 communicate with each other. When the first valve body 62 is arranged at a closed position at which the first valve body 62 contacts the seat surface 541, the communication between the shaft passage 501 and the chamber 46 is blocked. In other words, the first valve body 62 is arranged in the drive force transmitting body 61 to adjust the cross-sectional area of a passage extending between the external passage and the internal passage.

[0033] The pressure sensing mechanism 49 has a bellows 55, a plate-like pressure receiving body 56 joined with the bellows 55, and urging springs 57, 58. The urging spring 57 urges the pressure receiving body 56 toward the shaft body 50. The urging spring 58 urges the pressure receiving body 56 separately from the shaft body 50. A chamber 60 defined in the bellows 55 is under vac-

uum. The chamber 60 accommodates a stopper 591 extending from the lid 59 and a stopper 561 extending from the pressure receiving body 56. The stoppers 591, 561 are capable of contacting and separating from each other. The stoppers 591, 561 determine the minimum length of the bellows 55, which extends and contracts.

[0034] The pressure sensing mechanism 49, the pressure sensing chamber 47, and the chamber 60 form a pressure sensing portion. The pressure receiving body 56 of the pressure sensing mechanism 49 is urged by the pressure in the pressure sensing chamber 47 in the direction in which the drive force transmitting body 61 is driven. The position of the pressure receiving body 56 in the movement direction of the drive force transmitting body 61 is regulated in correspondence with the pressure in the pressure sensing chamber 47. The bellows 55 and the pressure receiving body 56 form a pressure sensing body the position of which in the movement direction of the drive force transmitting body 61 is regulated in correspondence with the pressure in the pressure sensing chamber 47.

[0035] A valve body 63 capable of contacting and separating from the pressure receiving body 56 is formed in the distal portion of the shaft body 50. In the following, the valve body 63 will be referred to as a second valve body 63. The second valve body 63 is capable of contacting and separating from the pressure receiving body 56 and provided in the drive force transmitting body 61 to adjust the cross-sectional area of a passage between the internal passage and the pressure sensing chamber 47.

[0036] The pressure receiving area of the pressure sensing body in the drive direction of the drive force transmitting body 61, or the pressure receiving area for receiving the pressure in the pressure sensing chamber 47, is greater than the closed area S (see Fig. 4) of the second valve body 63. When the pressure receiving body 56 and the second valve body 63 are held in contact with each other, the closed area S becomes equal to the pressure receiving area of the pressure receiving body 56 for receiving the pressure in the shaft passage 501.

[0037] A third valve body 64 is formed in the circumferential surface of the shaft body 50 in the chamber 46. The third valve body 64 contacts and separates from a seat surface 451 of the partition wall 45. An annular groove 503 is defined in the circumferential surface of the shaft body 50 between the third valve body 64 and the second valve body 63. The annular groove 503 communicates with the valve hole 52 and with the discharge chamber 132 through a passage 67. The annular groove 503 is a groove passage communicating with the discharge chamber 132 (the discharge pressure zone) and the valve hole 52 at a position between the second valve body 63 and the third valve body 64. When the third valve body 64 is arranged at an open position separate from the seat surface 451, the annular groove 503 communicates with the chamber 46. When the third valve body 64 is located at a closed position contacting the seat sur-

face 451, the communication between the annular groove 503 and the chamber 46 is blocked. The third valve body 64 is provided in the drive force transmitting body 61 to adjust the cross-sectional area of a passage extending between the external passage and the discharge chamber 132.

[0038] The passage 67, the annular groove 503, the chamber 46, and the passage 65 form a supply passage by which the refrigerant is supplied from the discharge chamber 132 to the control pressure chamber 121. The passage 65, the chamber 46, the communication port 502, the shaft passage 501, the pressure sensing chamber 47, and the passage 66 form a drawing passage by which the refrigerant is discharged from the control pressure chamber 121 to the suction chamber 131.

[0039] The control computer C, which executes the current supply control (duty ratio control) to the electromagnetic solenoid 38 of the displacement control valve 37, permits the current supply to the electromagnetic solenoid 38 when an air conditioner switch 68 is turned on. When the air conditioner switch 68 is turned off, the control computer C stops the current supply. The control computer C receives signals from a compartment temperature setting device 69 and a compartment temperature detection device 70. When the air conditioner switch 68 is held in a turned-on state, the control computer C controls the current supplied to the electromagnetic solenoid 38 in correspondence with the difference between a target temperature set through the compartment temperature setting device 69 and a detected temperature provided by the compartment temperature detection device 70. In the illustrated embodiment, the control computer C adjusts the duty ratio of the current supplied to the electromagnetic solenoid 38 in correspondence with the difference between the target temperature set through the compartment temperature setting device 69 and the detected temperature provided by the compartment temperature detection device 70.

[0040] If the variable displacement compressor operates with minimum displacement, or the current supply to the electromagnetic solenoid 38 is stopped (the duty ratio is 0%), with the vehicle engine E running, the first valve body 62 is urged by the urging forces of the urging springs 53, 42 to reach the closed position at which the first valve body 62 contacts the seat surface 541, with reference to Fig. 4. In this state, the third valve body 64 is located at the open position spaced from the seat surface 451. The operational state of the variable displacement compressor with the minimum displacement will be referred to as a minimum displacement operational state.

[0041] Referring to Fig. 4, when the first valve body 62 is at the closed position, the drive force transmitting body 61 is held in a first arrangement state in which the third valve body 64 is located at the open position when the first valve body 62 is at the closed position. When the drive force transmitting body 61 is maintained in the first arrangement state, the refrigerant is sent from the dis-

charge chamber 132 to the control pressure chamber 121. In this state, as indicated by the chain lines of Fig. 1, the inclination angle of the swash plate 22 becomes minimized.

[0042] When the inclination angle of the swash plate 22 is minimum, discharge pressure is low. The urging force of the compression spring 36 is set in such a manner that, when the inclination angle of the swash plate 22 is minimum, the pressure upstream from the check valve 32 in the discharge passage 27 becomes lower than the sum of the pressure downstream from the check valve 32 and the urging force of the compression spring 36. This causes the valve body 34 to close the valve hole 331, thus stopping circulation of the refrigerant in the external refrigerant circuit 28. In this state, thermal load decreasing operation is stopped.

[0043] When the variable displacement compressor 10 is started by turning on the air conditioner switch 68, the duty ratio of the current supplied to the electromagnetic solenoid 38 is controlled to become 100%. This control state is continued for a predetermined time (for example, several minutes) after the variable displacement compressor 10 is started.

[0044] In this control state, referring to Fig. 2, the third valve body 64 is located at the closed position at which the third valve body 64 contacts the seat surface 451 against the urging forces of the urging springs 53, 42. The first valve body 62 is arranged at the open position spaced from the seat surface 541. When the variable displacement compressor 10 operates in the minimum displacement operational state or is maintained in a deactivated state, the suction pressure, or the pressure in the suction chamber 131, is thus relatively high because the pressure in the variable displacement compressor 10 is equalized. Therefore, the pressure in the pressure sensing chamber 47 is also relatively high, and the pressure receiving body 56 and the second valve body 63 are spaced from each other by a great distance. In other words, the drive force transmitting body 61 is held in a second arrangement state in which the third valve body 64 is held at the closed position and the first valve body 62 is located at the open position. When the drive force transmitting body 61 is maintained in the second arrangement state in which the first valve body 62 is located at the open position when the third valve body 64 is at the closed position, the refrigerant flows from the control pressure chamber 121 to the suction chamber 131 through the chamber 46, the shaft passage 501, and the pressure sensing chamber 47. In this state, the refrigerant does not flow from the discharge chamber 132 to the control pressure chamber 121. This decreases the pressure in the control pressure chamber 121, or control pressure. As a result, the inclination angle of the swash plate 22 switches from the minimum value to the maximum value.

[0045] If the variable displacement compressor 10 is held in a stopped state for a relatively long time, liquid refrigerant may retain in the control pressure chamber 121. In this case, the liquid refrigerant is rapidly drained

from the control pressure chamber 121 to the suction chamber 131 through the drawing passage. This prevents foaming of the liquid refrigerant from hampering restoration of the inclination angle of the swash plate 22 from the minimum inclination angle to the maximum inclination angle. As a result, the swash plate 22 is allowed to quickly incline from the minimum inclination angle to the maximum inclination angle.

[0046] As the inclination angle of the swash plate 22 gradually increases from the minimum value, the discharge pressure gradually rises. The pressure upstream from the check valve 32 in the discharge passage 27 thus exceeds the sum of the pressure downstream from the check valve 32 and the urging force of the compression spring 36. If the inclination angle of the swash plate 22 is greater than the minimum value, the valve hole 331 opens to send the refrigerant from the discharge chamber 132 to the external refrigerant circuit 28. That is, circulation of the refrigerant in the external refrigerant circuit 28 is brought about, thus reducing thermal load.

[0047] After a predetermined time has elapsed with the duty ratio of the current supplied to the electromagnetic solenoid 38 maintained at 100%, such control of the duty ratio is performed in correspondence with the difference between the target compartment temperature and the detected compartment temperature. Fig. 3 illustrates an example of such control in a state of $0 < (\text{duty ratio}) < 100\%$. In this state, the first valve body 62 is arranged at the open position spaced from the seat surface 541 and the third valve body 64 is located at the open position spaced from the seat surface 451. When the drive force transmitting body 61 is held in a third arrangement state in which the first and third valve bodies 62, 64 are held at the respective open positions, the refrigerant flows from the discharge chamber 132 to the control pressure chamber 121 through the chamber 46. Also, the pressure receiving body 56 contacts and spaces from the second valve body 63 in correspondence with variation of the pressure in the pressure sensing chamber 47, or the suction pressure. In this manner, the suction pressure is controlled to become a target suction pressure that is set in accordance with the duty ratio of the current supplied to the electromagnetic solenoid 38.

[0048] The pressure receiving body 56 and the second valve body 63 are not constantly held in a separated state. The amount of the refrigerant drawn from the control pressure chamber 121 to the suction chamber 131 thus does not increase excessively. The operation efficiency of the variable displacement compressor 10 in variable displacement control is thus prevented from lowering.

[0049] The illustrated embodiment has the following advantages.

(1) When the variable displacement compressor 10 is started from the stopped state, the pressure in the suction chamber 131, which is the suction pressure zone, or the suction pressure, is relatively high.

Therefore, the opening degrees (the cross-sectional area of the opening) of the pressure receiving body 56 and the second valve body 63 are relatively great. This rapidly draws the liquid refrigerant from the control pressure chamber 121 to the suction chamber 131. Thus, in addition to the bleed passage 72, a great amount of refrigerant can be drawn from the control pressure chamber 121 to the suction chamber 131 as needed.

If the pressure in the suction chamber 131, or the pressure in the suction pressure zone, varies in such a manner as to pass the set suction pressure set in correspondence with the electromagnetic force of the electromagnetic solenoid 38 when the variable displacement compressor 10 is operated in the variable displacement operational state, the pressure receiving body 56 and the second valve body 63 contact and separate from each other. Since the pressure receiving body 56 and the second valve body 63 are not constantly held in a separated state, the amount of the refrigerant drawn from the control pressure chamber 121 to the suction chamber 131 does not increase excessively. This prevents the operation efficiency of the variable displacement compressor 10 in the variable displacement control from lowering.

(2) The first valve body 62, the third valve body 64, and the second valve body 63 are arranged sequentially in this order from the side corresponding to the electromagnetic solenoid 38 to the side corresponding to the pressure sensing mechanism 49. The annular groove 503, which is a portion of the supply passage, is defined around the drive force transmitting body 61 (the shaft body 50) and between the second valve body 63 and the third valve body 64. This arrangement allows the valve hole 52 in which the drive force transmitting body 61 is slidably received to function as a portion of the supply passage, thus simplifying the configuration of the displacement control valve 37.

(3) The pressure receiving area of the pressure sensing body, or the pressure receiving body 56, in the drive direction of the drive force transmitting body 61 is greater than the closed area S of the second valve body 63. If the pressure receiving area of the pressure sensing body, or the pressure receiving body 56, were equal to the closed area S of the second valve body 63, separation and contact between the pressure receiving body 56 and the second valve body 63 in the variable displacement operational state would become dependent solely on the pressure in the shaft passage 501, or the control pressure. In this case, the pressure in the control pressure chamber 121 would be controlled to become a set control pressure that is set in correspondence with the electromagnetic force of the electromagnet-

ic solenoid 38.

However, in the illustrated embodiment, the pressure receiving area of the pressure sensing body, or the pressure receiving body 56, in the drive direction of the drive force transmitting body 61 is greater than the closed area S of the second valve body 63. Such setting of the pressure receiving area is preferable for optimally controlling the pressure in the suction pressure zone, or the suction pressure, to the set suction pressure set in correspondence with the electromagnetic force of the electromagnetic solenoid 38.

(4) When the variable displacement compressor 10 is held in the minimum displacement operational state and the refrigerant circulation in the external refrigerant circuit 28 is maintained in a stopped state, the refrigerant must circulate in the variable displacement compressor 10 to lubricate sliding members of the compressor 10. The minimum displacement operational state is maintained by opening the third valve body 64 and thus supplying the refrigerant from the discharge chamber 132 to the control pressure chamber 121. However, if the control pressure chamber 121 and the suction chamber 131 communicated with each other with the first valve body 62 maintained in an open state, a refrigerant circulation path would form in the displacement control valve 37 but not in the variable displacement compressor 10. In this case, the sliding members would not be lubricated.

In the illustrated embodiment, the first valve body 62 formed in the cylindrical body 51 reliably blocks communication between the chamber 46 and the shaft passage 501 by contacting the seat surface 541. This prevents the refrigerant from leaking from the control pressure chamber 121 to the suction chamber 131 via the displacement control valve 37. The valve assembly 48, which has a configuration in which the shaft body 50 and the cylindrical body 51 are joined together, is a simple structure that reliably blocks communication between the chamber 46, which forms the external passage, and the shaft passage 501, or the internal passage, by means of the first valve body 62.

(5) In Japanese Laid-Open Patent Publication No. 2003-322086, which is explained above in the section of BACKGROUND OF THE INVENTION, the pressure sensing device senses the pressure in the control pressure chamber 121, or the control pressure. When starting control is switched to variable displacement control, refrigerant flows from the discharge pressure zone to the control pressure chamber, thus rapidly raising the control pressure. This may cause stoppers provided in the bellows to collide with each other, thus damaging the pressure sensing device.

[0050] The pressure sensing chamber 47, which forms the pressure sensing portion of the present invention, communicates with the suction chamber 131, or the suction pressure zone. Therefore, even if the control pressure rapidly rises, the stoppers 561, 591 provided in the bellows 55 are prevented from striking each other, and the pressure sensing device is prevented from being damaged. Also, durability of the bellows 55 may be improved due to suppressed vibration of the bellows 55.

[0051] The illustrated embodiment may be modified in the following forms.

[0052] As illustrated in Fig. 5, a third valve body 64A, a first valve body 62, and a second valve body 63 may be arranged sequentially in this order from the side corresponding to the electromagnetic solenoid 38 to the side corresponding to the pressure sensing portion. A chamber 71 accommodating the third valve body 64A communicates with a discharge chamber 132. A valve hole 543 is defined in a valve seat plate 54 in such a manner as to communicate with a chamber 46. The third valve body 64A contacts and separates from a seat surface 542 of the valve seat plate 54, thus permitting and blocking communication between the chamber 71 and the valve hole 543.

[0053] The bleed passage 72 may be omitted. In this case, the drawing passage is the sole passage to connect the control pressure chamber 121 and the suction chamber 131.

[0054] A pressure sensing portion provided with a pressure sensing body having a diaphragm may be used.

[0055] A pressure sensing portion using a piston type movable wall as a pressure sensing body may be employed.

[0056] A displacement control valve includes an electromagnetic solenoid and a drive force transmitting body. A pressure sensing chamber communicates with a suction chamber and a pressure sensing body is located in the pressure sensing chamber. An internal passage is provided in the transmitting body and an external passage is provided about the transmitting body. The first to third valve bodies are provided at the transmitting body. The first valve body adjusts a cross-sectional area of a passage between the external passage and the internal passage. The second valve body adjusts a cross-sectional area of a passage between the internal passage and the pressure sensing chamber. The third valve body adjusts a cross-sectional area of a passage between the external passage and a discharge chamber. The transmitting body is switched among first, second, and third arrangement states by the electromagnetic solenoid. With the transmitting body at the first arrangement state, the third valve body is at an open position when the first valve body is at a closed position. With the transmitting body at the second arrangement state, the first valve body is at an open position when the third valve body is at a closed position. With the transmitting body at the third arrangement state, both of the first and third valve bodies are at the open position.

Claims

1. A displacement control valve of a variable displacement compressor, wherein the compressor draws refrigerant from a suction pressure zone and discharges the refrigerant to a discharge pressure zone, and controls displacement according to a pressure in a control pressure chamber, the displacement control valve comprising:

an electromagnetic solenoid;

a drive force transmitting body movable along a movement axis, the drive force transmitting body receiving, from the electromagnetic solenoid, a drive force in a drive direction along the movement axis;

a pressure sensing portion having a pressure sensing chamber that communicates with the suction pressure zone and a pressure sensing body that receives a pressure in the pressure sensing chamber, wherein the pressure sensing body is urged in the drive direction by the pressure in the pressure sensing chamber, the position of the pressure sensing body in a direction along the movement axis is regulated in accordance with the pressure in the pressure sensing chamber;

an internal passage provided in the drive force transmitting body, the internal passage being connectable to the pressure sensing chamber;

an external passage provided about the drive force transmitting body, the external passage being connected to the control pressure chamber;

a first valve body provided at the drive force transmitting body, the first valve body adjusting a cross-sectional area of a passage between the external passage and the internal passage;

a second valve body contactable with and separable from the pressure sensing body, the second valve body adjusting a cross-sectional area of a passage between the internal passage and the pressure sensing chamber; and

a third valve body provided at the drive force transmitting body, the third valve body adjusting a cross-sectional area of a passage between the external passage and the discharge pressure zone,

wherein the drive force transmitting body is switched among first, second, and third arrangement states by the electromagnetic solenoid, wherein, with the drive force transmitting body at the first arrangement state, the third valve body is at an open position when the first valve body is at a closed position, wherein, with the drive force transmitting body at the second arrangement state, the first valve body is at an open position when the third valve body is at a

closed position, and wherein, with the drive force transmitting body at the third arrangement state, both of the first and third valve bodies are at the open position.

2. The displacement control valve according to claim 1, wherein the first valve body, the third valve body, and the second valve body are arranged in this order from a side corresponding to the electromagnetic solenoid toward a side corresponding to the pressure sensing portion, wherein the displacement control valve has a valve hole that slidably receives the drive force transmitting body, wherein a groove passage is formed in an circumferential surface of the drive force transmitting body between the second valve body and the third valve body, the groove passage being capable of connecting the discharge pressure zone and the external passage to each other, and wherein the third valve body adjusts a cross-sectional area of a passage between the groove passage and the external passage.
3. The displacement control valve according to claim 2, further comprising a partition wall that separates the pressure sensing chamber and the external passage from each other, wherein the valve hole extends through the partition wall, and wherein the third valve body is contactable with and separable from a seat surface of the partition wall provided about the opening of the valve hole.
4. The displacement control valve according to claim 3, wherein the first and third valve bodies are located in the external passage, and wherein the second valve body is located in the pressure sensing chamber.
5. The displacement control valve according to claim 2, wherein the drive force transmitting body includes a shaft body having the internal passage and a cylindrical body fixed to the shaft body, wherein the second valve body and the third valve body are formed in the shaft body, and the first valve body is formed in the cylindrical body.
6. The displacement control valve according to any one of claims 1 to 5, wherein a pressure receiving area in the drive direction of the pressure sensing body is larger than a closed area of the second valve body.
7. The displacement control valve according to any one of claims 1 to 6, wherein the pressure sensing body includes a bellows.
8. The displacement control valve according to any one of claims 1 to 7, wherein the compressor includes a supply passage for supplying refrigerant in the discharge pressure zone to the control pressure cham-

ber, and a discharge passage for discharging refrigerant in the control pressure chamber to the suction pressure zone, wherein the internal passage forms a part of the discharge passage, and wherein the external passage forms a part of the supply passage and a part of the discharge passage. 5

9. A variable displacement compressor comprising:

the displacement control valve according to any one of the claims 1 to 8; and
a bleed passage connecting the control pressure chamber and the suction pressure zone to each other. 10

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Fig.1

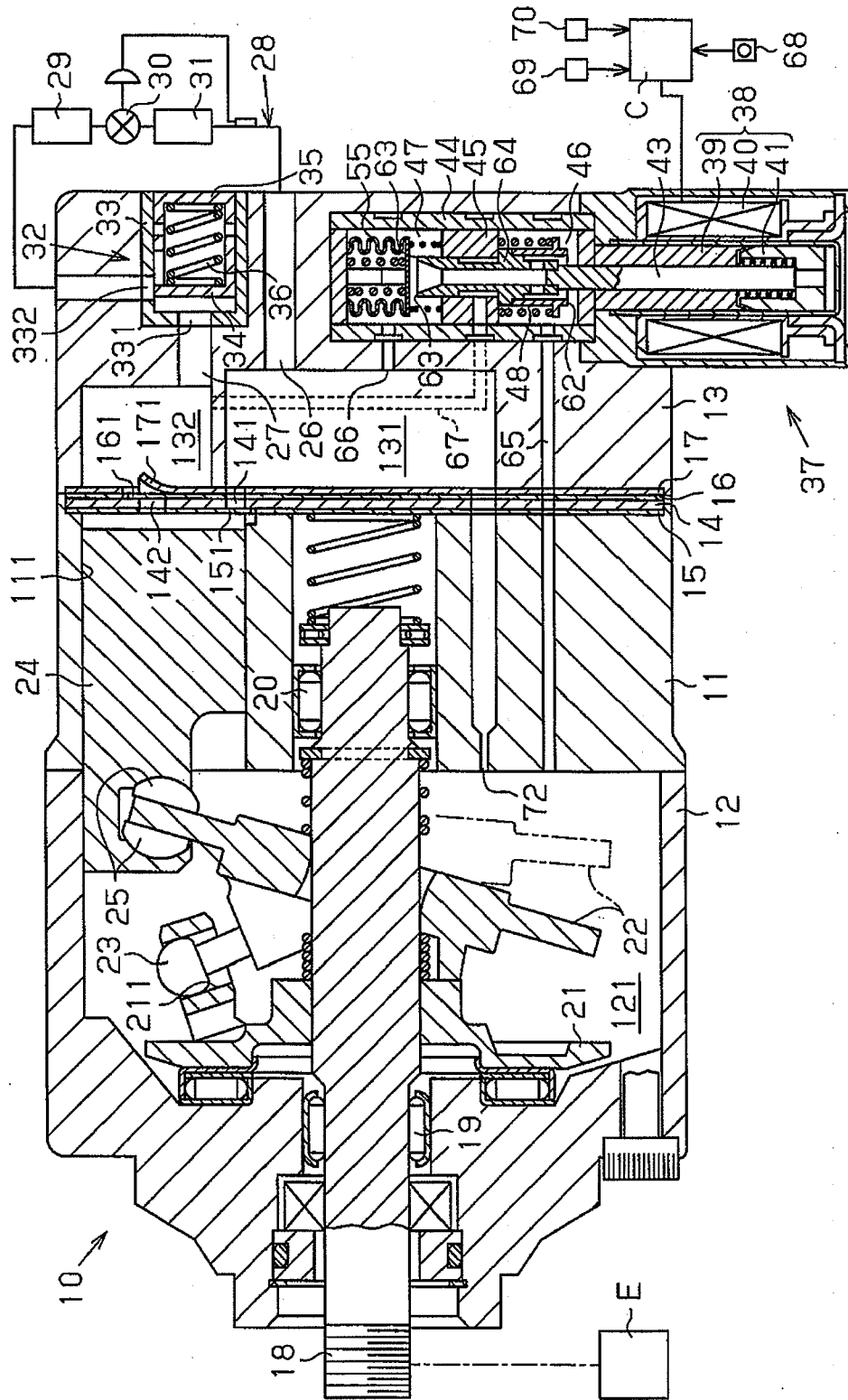
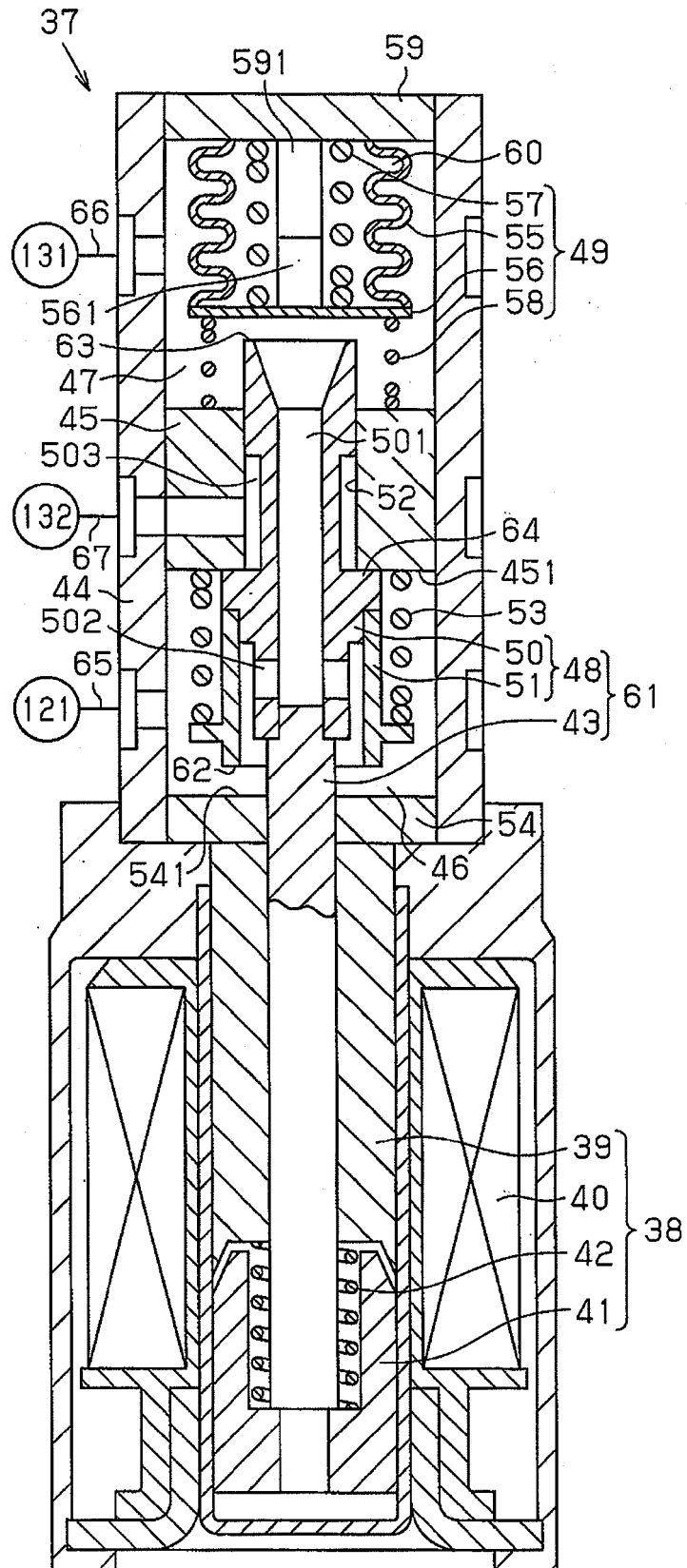


Fig.2



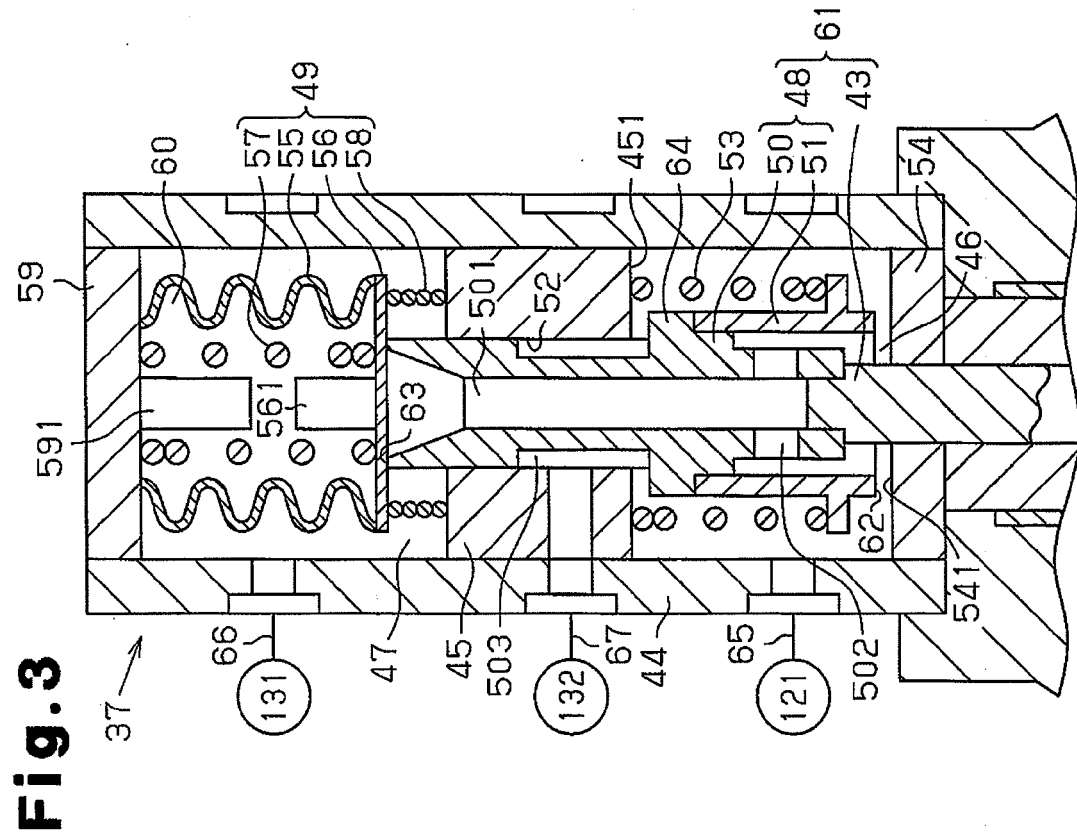
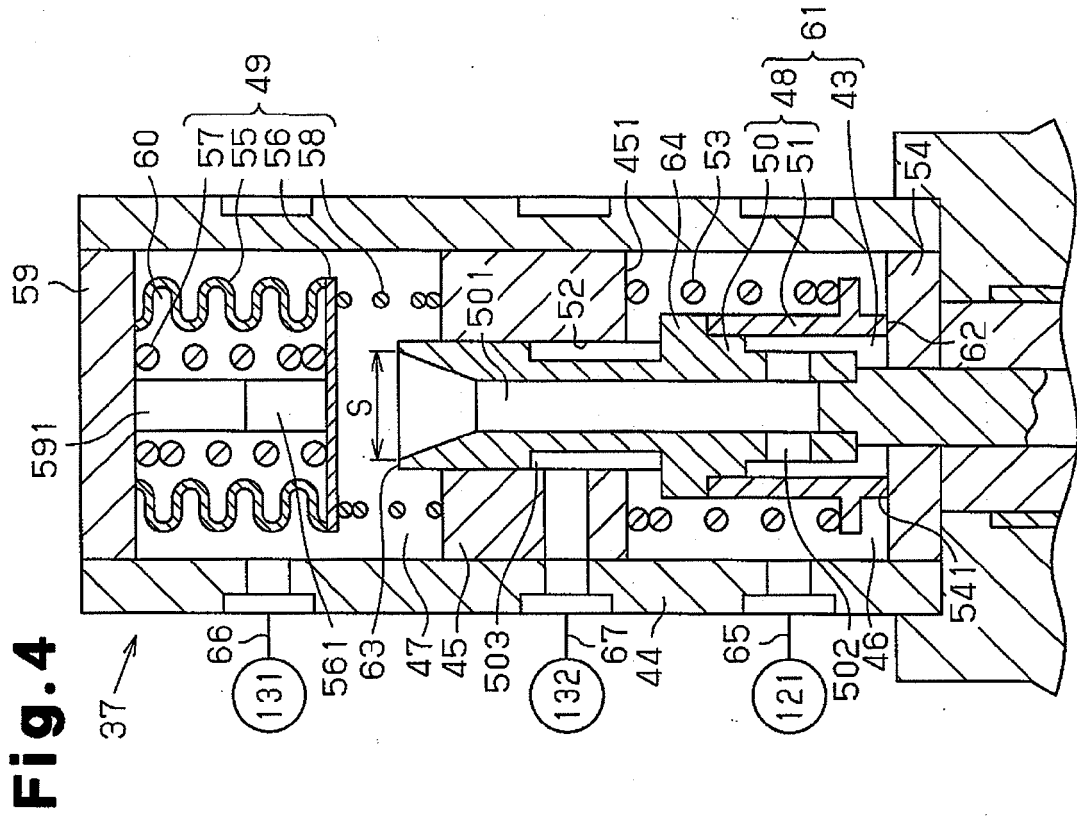
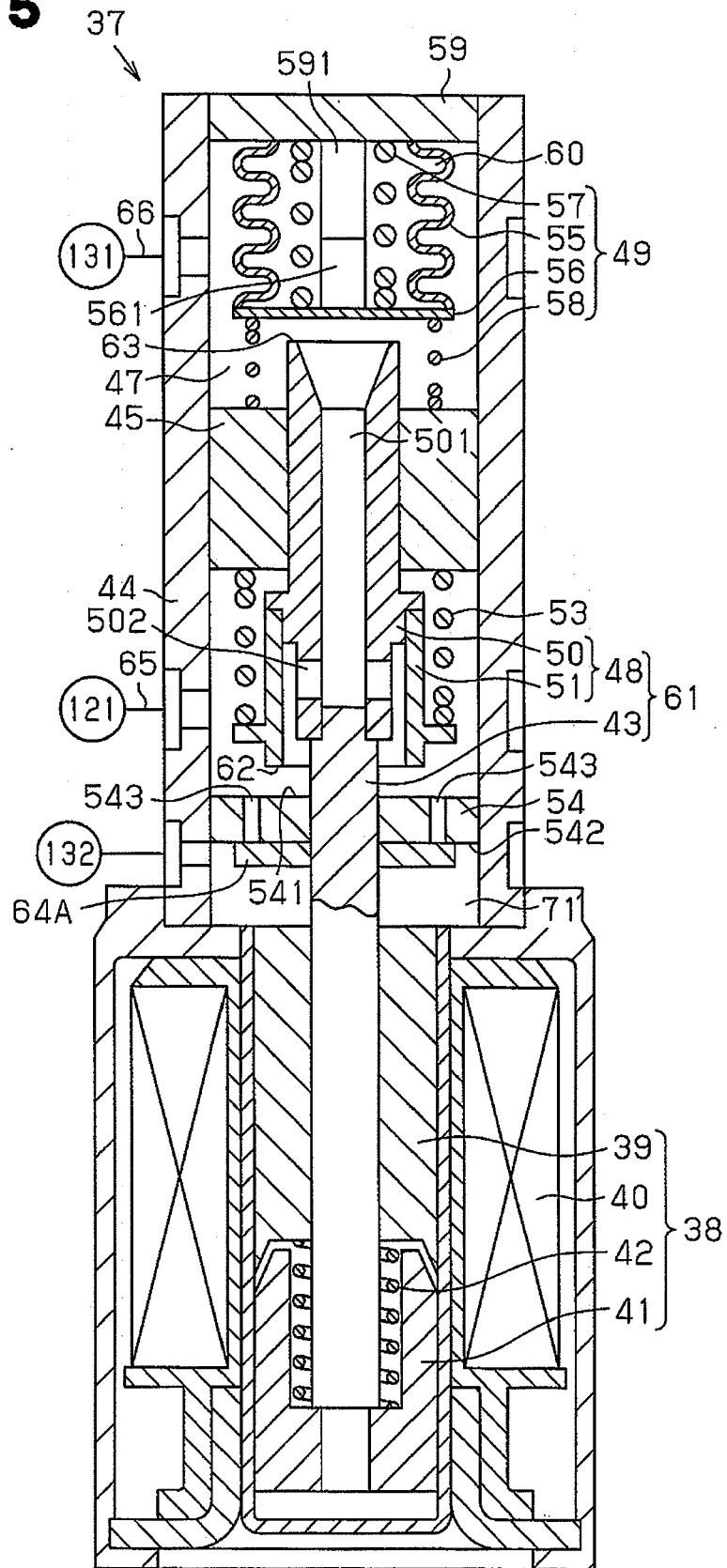


Fig.5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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