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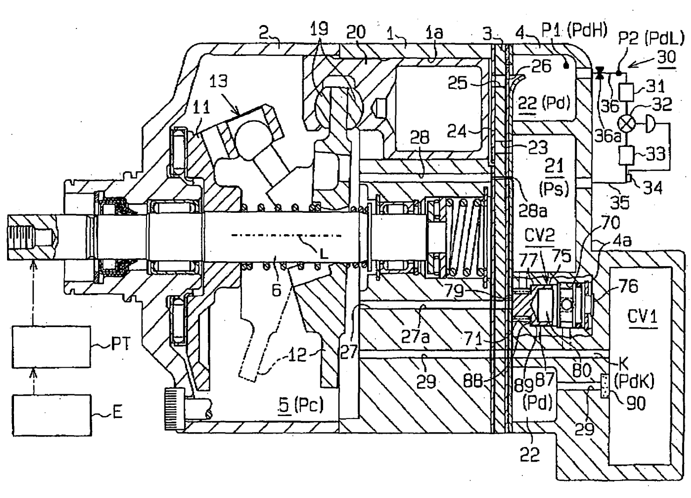
(54) Displacement control mechanism for variable displacement compressors

(57) A displacement control mechanism used in a variable displacement compressor for controlling a displacement of the compressor includes a first control valve located on a supply passage and a second control valve located on a first bleed passage. The second control valve includes a backpressure chamber having substantially the same pressure atmosphere as a region of the supply passage downstream of the first control valve and a spool including a back surface that is located in the backpressure chamber. The spool reduces an opening degree of the first bleed passage when a pressure in the backpressure chamber is increased. The spool blocks a communication between the backpressure chamber and the first bleed passage via a clearance formed around a cylindrical outer peripheral surface of the spool in the second control valve when the spool sets the first bleed passage at a minimum opening degree.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a displacement control mechanism for controlling the displacement of a variable displacement compressor that forms a part of 6 refrigerant circulation circuit of an air-conditioner. The displacement of the compressor is varied in accordance with the pressure in a crank chamber of the compressor.

[0002] There is known a control mechanism shown in FIG. 15. According to the mechanism, the compressor displacement is controlled by adjusting the pressure in crank chamber 153 (or crank pressure Pc). Namely, in a swash plate type variable displacement compressor (hereinafter the compressor), the crank chamber 153 communicates with a suction chamber 155 via a bleed passage 154. A discharge chamber 151 of the compressor communicates with the crank chamber 153 via a supply passage 152 on which a control valve 156 is arranged. The amount of refrigerant gas introduced into the crank chamber 153 via the supply passage 152 is controlled by adjusting the opening degree of the control valve 156, and the crank pressure Pc is determined in accordance with the relation between the amounts of refrigerant gas introduced into and bleeding from the crank chamber 153.

[0003] A fixed throttle 158 is formed in the bleed passage 154 so that the refrigerant gas bleeds slowly from the crank chamber 153 to the suction chamber 155. Thus, even when the amount of the refrigerant gas supplied from the discharge chamber 151 to the crank chamber 153 via the supply passage 152 is small, the crank pressure Pc is steadily increased. Therefore, when the control valve 156 increases the opening degree of the supply passage 152, the crank pressure Pc is rapidly increased. Consequently, appropriate response in decreasing the compressor displacement is obtained.

[0004] Also, an amount of blow-by gas from a cylinder bore 157 to the crank chamber 153 leaks to the suction chamber 155 via the bleed passage 154. The refrigerant gas moves from the discharge chamber 151 to the suction chamber 155 via the crank chamber 153 as mentioned above, such movement of the refrigerant being a kind of internal leaking. However, the amount of the above leaking blow-by gas and the amount of the above moving refrigerant gas are reduced as much as possible by the provision of the fixed throttle 158. Consequently, decrease in efficiency of the compressor caused by the provision of the displacement control mechanism is prevented.

[0005] However, the fixed throttle 158 provided in the bleed passage 154 causes the pressure in the crank chamber 153 to be slowly reduced, thereby deteriorating the response of the compressor in increasing the displacement. Especially, upon starting the compressor, the crank pressure Pc tends to be increased excessively because the liquid refrigerant accumulated in the crank chamber 153 evaporates and the fixed throttle 158 prevents smooth flow of refrigerant gas from the crank chamber 153. Therefore, even when the control valve 156 closes the supply passage 152 so as to increase the displacement of the compressor in response to the requirement for cooling shortly after starting the compressor, it takes time before the displacement of the compressor is actually increased, so that the cooling performance shortly after a start-up of an air-conditioner deteriorates.

[0006] To solve such problems, it is proposed to provide a second control valve 161 for controlling the opening degree of the bleed passage 154 in addition to the control valve (first control valve) 156, as shown in FIG. 16 (e.g. Japanese Unexamined Patent Publication 2002-21721). In the proposed structure, a region K is provided in the supply passage 152 downstream of the position of first control valve 156 (i.e. the position of valve opening adjustment) and upstream of the fixed throttle 169, as shown in FIG. 16. The second control valve 161 is a spool type valve that includes a spool 162 and a backpressure chamber 166 into which the pressure in the region K is introduced. A valve chamber 167 of the second control valve 161 forms a part of the bleed passage 154 and communicates with the suction chamber 155. The valve chamber 167 also communicates with the crank chamber 153 via a valve hole 168 that forms the upstream part of the bleed passage 154.

[0007] The spool 162 is movably disposed in a spool-supporting recess 164 that is formed in a compressor housing. The spool 162 includes a valve portion 162a that is located In the valve chamber 167 and a back surface 162b that is located in the backpressure chamber 166. The spool 162 (or the valve portion 162a) is positioned by various forces applied thereto such as urging force based on the pressure in the backpressure chamber 166 acting on the back surface 162b in the direction to close the valve, urging force of a spring 165 acting in the valve opening direction and force of the crank pressure Pc that is applied in the valve opening direction.

[0008] When the first control valve 156 closes the supply passage 152, a pressure PdK in the backpressure chamber 166 of the second control valve 161 is substantially the same as the crank pressure Pc and, therefore, the spool 162 of the second control valve 161 is positioned by the spring 165 where the valve hole 168 is wide opened at a maximum opening degree. When the bleed passage 154 is wide opened by the second control valve 161, flowing of the refrigerant from the crank chamber 153 to the suction chamber 155 is promoted. Therefore, closing the supply passage 152 by the first control valve 156 so as to increase the displacement of the compressor shortly after starting the compressor, the displacement of the compressor is immediately increased, so that the cooling performance shortly after a start-up of air conditioner is improved.

[0009] A spring having a small spring force is utilized as the spring 165. Thus, when the supply passage 152 is opened even slightly by the first control valve 156 and the pressure PdK in the region K exceeds the crank pressure Pc, the spool 162 moves against the urging force of the spring 165, and the valve portion 162a sets the valve hole 168 at a minimum opening degree that is not zero. Therefore, when the valve hole 168 is thus set at the minimum opening degree that is not zero, the second control valve 161 functions similarly as the above-described fixed throttle 158 shown in FIG. 15, and the decrease in the efficiency of the compressor which is caused by having the displacement control mechanism is prevented.

[0010] However, the second control valve 161 is arranged such that the clearance between the outer peripheral surface of the spool 162 and the inner peripheral surface of the spool-supporting recess 164 is small, so that the fluid communication between the backpressure chamber 166 and the valve chamber 167 via the clearance is blocked, and the decrease in the efficiency of the compressor due to the leak of the refrigerant gas from the backpressure chamber 166 to the valve chamber 167 is prevented. However, foreign substances tend to be caught between the outer peripheral surface of the spool 162 and the inner peripheral surface of the spool-supporting recess 164, thereby causing poor sliding movement of the spool 162.

[0011] In order to solve such problems, the alternative embodiment of the above prior art reference proposes the use of a bellows instead of the spool 162 and the spring 165. Using the bellows that is elastic and stretchable and serves as a partition wall shutting off the communication between the back pressure chamber and the valve chamber without any sliding contact of moving part of the second control valve with the compressor housing, the clearance between the moving part of the second control valve and the compressor housing is set large enough. However, the bellows becomes larger with a decrease of its spring constant. Thus, in comparison to the case that the spool 162 and the spring 165 are used in combination, the second control valve having incorporated therein a bellows is disadvantageously large-sized.

SUMMARY OF THE INVENTION

[0012] The present invention provides a displacement control mechanism for a variable displacement compressor that prevents the operation failure of the spool of a second control valve that adjusts the opening degree of the bleed passage.

[0013] According to the present invention, a displacement control mechanism is used in a variable displacement compressor for controlling a displacement of the compressor. The compressor partially forms a refrigerant circulation circuit of an air-conditioner. The displacement of the compressor is varied in accordance with a pressure in a crank chamber of the compressor. The refrigerant circulation circuit includes a suction pressure region and a discharge pressure region. The displacement control mechanism includes a first bleed passage, a supply passage, a first control valve and a second control valve. The first bleed passage interconnects the crank chamber and the suction pressure region. The supply passage interconnects the crank chamber and the discharge pressure region. The first control valve is located on the supply passage for controlling an opening degree of the supply passage. The second control valve is located on the first bleed passage. The second control valve also includes a backpressure chamber and a spool. The backpressure chamber has substantially the same pressure atmosphere as a region of the supply passage downstream of the first control valve. The spool includes a back surface that is located in the backpressure chamber. The spool has a cylindrical outer peripheral surface. The spool reduces an opening degree of the first bleed passage when a pressure in the backpressure chamber that is applied to the back surface is increased. The spool blocks a communication between the backpressure chamber and the first bleed passage via a clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve when the spool sets the first bleed passage at a minimum opening degree.

BRIEF DISCRIPTION OF THE DRAWINGS

[0014] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. Aspect of the invention 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 longitudinal cross-sectional view of a variable displacement compressor according to a first preferred embodiment;

FIG. 2 is a cross-sectional view of a first control valve;

FIG. 3A is a partially enlarged cross sectional view of the variable displacement compressor around a second control valve;

FIG. 3B is a schematic view showing cross section areas of a valve chamber and a valve hole for explaining conditional inequalities;

FIG. 4A is a cross-sectional view explaining an action of the second control valve;

FIG. 4B is a cross-sectional view explaining the action of the second control valve;

FIG. 5 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a second preferred embodiment;

FIG. 6 is a cross-sectional view explaining an action of the second control valve;

FIG. 7 is a cross-sectional view of a first control valve including a second control valve therein according to a third preferred embodiment;

FIG. 8 is a partially enlarged cross-sectional view of the first control valve including the second control valve therein according to the third preferred embodiment;

FIG. 9 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a first alternative embodiment;

FIG. 10 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a second alternative embodiment;

FIG. 11 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a third alternative embodiment;

FIG. 12 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a fourth alternative embodiment;

FIG. 13 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a fifth alternative embodiment;

FIG. 14 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to a sixth alternative embodiment;

FIG. 15 is a schematic view of a variable displacement compressor according to prior art; and

FIG. 16 is a partially enlarged cross-sectional view of a variable displacement compressor around a second control valve according to prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The following will describe a preferred embodiment of the present invention. In the first preferred embodiment, the present invention is applied to a swash plate type variable displacement compressor (hereinafter the compressor) that is used in a vehicle air-conditioner for compressing refrigerant gas.

[0016] Referring to FIG. 1, the compressor includes a cylinder block 1, a front housing 2, a valve plate assembly 3 and a rear housing 4. In FIG. 1, the left side and the right side respectively correspond to the front side and the rear side of the compressor. The front housing 2 is fixed to the front end of the cylinder block 1, and the rear housing 4 is fixed to the rear end of the cylinder block 1 via the valve plate assembly 3. A compressor housing includes the cylinder block 1, the front housing 2 and the rear housing 4. A crank chamber 5 is defined by the cylinder block 1 and the front housing 2. A drive shaft 6 is rotatably supported in the crank chamber 5. A lug plate 11 is rotatably fixed to the drive shaft 6 in the crank chamber 5.

[0017] The front end of the drive shaft 6 is operatively connected to a vehicle engine E as an external drive source via a power transmission mechanism PT. The power transmission mechanism PT is a clutch mechanism (e.g. an electromagnetic clutch) that selectively transmits and blocks driving power according to electric control from an external device, or a continuous transmission type clutchless mechanism (e.g. the combination of belt and pulley) that dispenses with the above clutch mechanism. In the first preferred embodiment, the clutchless type power transmission mechanism PT is utilized.

[0018] A swash plate 12 as a cam plate is accommodated in the crank chamber 5. The swash plate 12 is slidably and inclinably supported by the drive shaft 6. A hinge mechanism 13 is interposed between the lug plate 11 and the swash plate 12. Thus, a hinge connection between the lug plate 11 and the swash plate 12 via the hinge mechanism 13 and the support of the swash plate 12 by the drive shaft 6 allow the swash plate 12 to rotate integrally with the lug plate 11 and the drive shaft 6 as well as to incline with respect to the drive shaft 6 in accordance with the sliding movement of the swash plate 12 relative to the drive shaft 6 in the axial direction of the drive shaft 6.

[0019] A plurality of cylinder bores 1a are formed in the cylinder block 1 extending axially through the cylinder block 1 and arranged around the drive shaft 6. Single-headed pistons 20 are each accommodated in the respective cylinder bores 1a for reciprocation therein. The front and rear openings of the cylinder bores 1 a are respectively closed by the valve plate assembly 3 and the pistons 20. Compression chambers are defined in the cylinder bores 1a, and the volume of the compression chambers is varied in accordance with the reciprocating movement of the pistons 20. Each of the pistons 19 is engaged with the swash plate 12 via a pair of shoes 19, so that the rotation of the swash plate 12 in accordance with the drive shaft 6 is converted into reciprocating linear movement of the pistons 20.

[0020] A suction chamber 21 and a discharge chamber 22 are defined between the valve plate assembly 3 and the rear housing 4. The suction chamber 21 is located in the middle region of the rear housing 4 and is surrounded by the discharge chamber 22. A suction port 23 and a suction valve 24 are formed in the valve plate assembly 3 for each of the cylinder bores 1 a. The suction valve 24 is adapted to open and close the suction port 23. A discharge port 25 and a discharge valve 26 are also formed in the valve plate assembly 3 for each of the cylinder bores 1a. The suction chamber 21 communicates with each of the cylinder bores 1 a via the corresponding suction port 23, and each of the cylinder bores 1 a communicates with the discharge chamber 22 via the corresponding discharge port 25.

[0021] As each of the pistons 20 moves from the top dead center toward the bottom dead center, the refrigerant gas is drawn into the corresponding cylinder bore 1 a via the suction port 23 and the suction valve 24. As each of the pistons 20 moves from the bottom dead center toward the top dead center, the refrigerant gas introduced into the cylinder bore 1 a is compressed to a predetermined pressure and is discharged into the discharge chamber 22 via the discharge port 25 and the discharge valve 26.

[0022] An inclination angle of the swash pate 12, which is defined as an angle made between the swash plate 12 and a hypothetical plane perpendicular to an axis L of the drive shaft 6 is varied in accordance with the pressure in the crank chamber 5 (a crank pressure Pc). The inclination angle of the swash plate 12 is randomly determined between a minimum inclination angle as indicated by a solid line in FIG. 1 and a maximum inclination angle as indicated by a chain double-dashed line in FIG. 1.

[0023] A displacement control mechanism for controlling the crank pressure Pc which is concerned with the controlling of the inclination angle of the swash plate 12 includes a first bleed passage 27, a second bleed passage 28, a supply passage 29, a first control valve CV1 and a second control valve CV2. The first and second bleed passages 27 and 28 interconnect the crank chamber 5 and the suction chamber 21 as a suction pressure (Ps) region. The second control valve CV2 is arranged on the first bleed passage 27. The second bleed passage 28 has a fixed throttle 28a and extends through the cylinder block 1 and the valve plate assembly 3. The fixed throttle 28a located in the second bleed passage 28 is formed such that the part of the second bleed passage 28 extending through the valve plate assembly 3 is narrower than that extending through the cylinder block 1.

[0024] The supply passage 29 interconnects the discharge chamber 22 as a discharge pressure (Pd) region and the crank chamber 5. The first control valve CV1 is arranged on the supply passage 29 for adjusting the opening degree of the supply passage 29. The supply passage 29 extends through the valve plate assembly 3 downstream of the first control valve CV1 or on a side of the crank chamber 5. The first control valve CV1 and the second control valve CV2 respectively adjust the opening degree of the supply passage 29 and the first bleed passage 27. By so doing, the balance between the amount of high-pressure discharge gas introduced from the discharge chamber 22 into the crank chamber 5 via the supply passage 29 and the amount of the refrigerant gas flowing from the crank chamber 5 into the suction chamber 21 via the first and second bleed passages 27 and 28 is controlled, and the crank pressure Pc is determined, accordingly. Pressure difference between the crank pressure Pc and the internal pressure in the cylinder bores 1 a via the pistons 20 is changed in accordance with the variation of the crank pressure Pc, and the inclination angle of the swash plate 12 is varied, accordingly. Consequently, the stroke of pistons 20, that is, the displacement of the compressor is adjusted.

[0025] For example, when the first control valve CV1 reduces the opening degree of the supply passage 29 and the crank pressure Pc is decreased, the inclination angle of the swash plate 12 is increased, and the displacement of the compressor is increased. On the other hand, when the first control valve CV1 increases the opening degree of the supply passage 29 and the crank pressure Pc is increased, the inclination angle of the swash plate 12 is decreased, and the displacement of the compressor is decreased.

[0026] A refrigerant circulation circuit (or refrigerant cycle) of the vehicle air-conditioner includes the above-described compressor and an external refrigerant circuit 30. The external refrigerant circuit 30 includes a gas cooler 31, an expansion valve 32 and an evaporator 33. A circulation pipe 35 for the refrigerant is provided on the downstream side of the external refrigerant circuit 30, interconnecting the outlet of the evaporator 33 and the suction chamber 21 of the compressor. A circulation pipe 36 for the refrigerant is provided on the upstream side of the external refrigerant circuit 30, interconnecting the discharge chamber 22 of the compressor and the inlet of the gas cooler 31.

[0027] As shown in FIG. 2, the first control valve CV1 includes a supply valve portion in the upper half thereof as seen on the drawing of FIG. 2 and a solenoid portion 60 in the lower half. The supply valve portion adjusts the opening degree (throttle degree) of the supply passage 29 that Interconnects the discharge chamber 22 and the crank chamber 5. The solenoid portion 60 is an actuator for controlling the operation of a valve rod 40 arranged in the control valve CV1 in response to a control signal from an external device. The valve rod 40 is a rod-like member which includes a partition wall portion 41 at the top of the valve rod 40, a connection part 42, a valve body 43 at the middle of the valve rod 40 and a guide rod 44 at the base of the valve rod 40. The valve body 43 is a part of the guide rod 44.

[0028] A valve housing 45 for the first control valve CV1 includes a valve body housing 45a forming its upper part and an actuator housing 45b forming its lower part. A valve accommodation chamber 46, a communication passage 47 and a pressure sensing chamber 48 are defined in the valve body housing 45a in this order as seen from the lower side of FIG. 2. The valve rod 40 is arranged in the valve accommodation chamber 46 and the communication passage 47 for movement in the direction of the axis of the valve housing 45, that is, movement in the vertical direction as seen in FIG. 2. The partition wall portion 41 of the valve rod 40 is inserted through the communication passage 47 thereby to shut off the communication between the pressure sensing chamber 48 and the communication passage 47.

[0029] Ports 51 and 52 are formed through the peripheral wall of the valve body housing 45a. The port 51 communicates with the valve accommodation chamber 46, and the port 52 communicates with the communication passage 47, respectively. The valve accommodation chamber 46 communicates with the discharge chamber 22 of the compressor via the port 51 and the upstream part of the supply passage 29. The communication passage 47 communicates with the crank chamber 5 of the compressor via the port 52 and the downstream part of the supply passage 29. The valve accommodation chamber 46 and the communication passage 47 form a part of the supply passage 29.

[0030] The valve body 43 of the valve rod 40 is located in the valve accommodation chamber 46. A valve seat 53 is formed at the step portion located between the valve accommodation chamber 46 and the communication passage 47, and the communication passage 47 functions as a valve hole. When the valve rod 40 moves upward from the position of FIG. 2, where the communication passage 47 (or the supply passage 29) is opened, to a position where the valve body 43 contacts the valve seat 53, that is, a planar surface 43a of the valve body 43 contacts a planar surface 53a of the valve seat 53, the communication passage 47 (the supply passage 29) is closed.

[0031] A bellows 50 is accommodated in the pressure sensing chamber 48, The upper end of the bellows 50 is fixed to the valve housing 45. The top of the partition wall portion 41 of the valve rod 40 is fitted into the lower end of the bellows 50. A first pressure chamber 54 that is located inside the bellows 50 and a second pressure chamber 55 that is located outside the bellows 50 are defined in the pressure sensing chamber 48 by the bellows 50 that has a cylindrical shape with a bottom.

[0032] As shown in FIG. 1, a throttle 36a is formed in the circulation pipe 36 between the discharge chamber 22 and the external refrigerant circuit 30. Referring back to FIG. 2, the first pressure chamber 54 communicates via a first pressure introducing passage 37 with the discharge chamber 22 at a first pressure monitoring point P1 that is located upstream of the throttle 36a. The second pressure chamber 55 communicates via a second pressure introducing passage 38 with the circulation pipe 36 at a second pressure monitoring point P2 that is located downstream of the throttle 36a. Thus, a monitored pressure PdH at the first pressure monitoring point P1 is introduced into the first pressure chamber 54, and a monitored pressure PdL at the second pressure monitoring point P2 is introduced into the second pressure chamber 55.

[0033] The lower end of the bellows 50 vertically moves in accordance with the pressure difference (PdH - PdL) between the pressures on opposite sides of the throttle 36a. Thus, positioning of the valve rod 40 (the valve portion 43) is determined by varying the pressure difference. The pressure difference (PdH - PdL) between the pressures on opposite sides of the throttle 36a varies depending on the refrigerant flow rate in the refrigerant circulation circuit. For example, when the refrigerant flow rate is increased, the pressure difference (PdH - PdL) is increased. On the other hand, when the refrigerant flow rate is decreased, the pressure difference (PdH - PdL) is decreased. The bellows 50 operates on the valve body 43 such that the displacement of the compressor is changed so as to cancel the variation of the pressure difference (PdH - PdL).

[0034] The solenoid portion 60 of the first control valve CV1 includes an accommodation cylinder 61 that has a cylindrical shape with a bottom in the middle of the actuator housing 45b. A fixed core 62 of a column shape is fitted in the upper opening of the accommodation cylinder 61. Thus, a solenoid chamber 63 is defined in the lower portion of the accommodation cylinder 61.

[0035] A movable core 64 is axially movable and accommodated in the solenoid chamber 63. A guide hole 65 extends through the center of the fixed core 62 in the axial direction of the valve rod 40. The guide rod 44 of the valve rod 40 is arranged in the guide hole 65 so as to move in the axial direction of the valve rod 40. The guide rod 44 is fitted into the movable core 64. Thus, the movable core 64 and the valve rod 40 vertically move together. A spring 66 is accommodated between the fixed core 62 and the movable core 64 in the solenoid chamber 63 for urging the valve rod 40 in such direction that causes the valve body 43 to move away from the valve seat 53.

[0036] A coil 67 is wound around the outer periphery of the accommodation cylinder 61 over a range covering the fixed core 62 and the movable core 64. Driving signal is transmitted from a driving circuit 68a to the coil 67, based on the command from a control device 68 in accordance with air-conditioning load. A magnitude of the electromagnetic force (or electromagnetic attraction) in accordance with an amount of electric power supplied to the coil 67 is generated between the fixed core 62 and the movable core 64. The electromagnetic force is transmitted to the valve rod 40 (the valve body 43) through the movable core 64. Controlling to energize the coil 67 is performed by adjusting the voltage applied across the coil 67, and duty ratio is utilized in the first preferred embodiment.

[0037] The solenoid portion 60 of the first control valve CV1 varies the electromagnetic force that is applied to the valve body 43 in accordance with the amount of the electric power supplied from an external device. In the first control valve CV1, therefore, control target (set pressure difference) for the pressure difference (PdH - PdL) between the pressures on opposite sides of the throttle 36a, that is, a standard for positioning the valve body 43 by the bellows 50 is changed by varying the electromagnetic force that is applied to the valve body 43. To put in other words, the first control valve CV1 is constructed to internally autonomously position the valve rod 40 (the valve body 43) in accordance with the variation of the pressure difference (PdH - PdL) between the first and second pressure monitoring points P1 and P2 such that the set pressure difference determined by the amount of the electric power supplied to the coil 67 is maintained.

[0038] The set pressure difference of the first control valve CV1 is varied by adjusting the amount of the electric power supplied to the coil 67 from the external device. For example, when the duty ratio that is commanded from the control device 68 to the driving circuit 68a is increased, electromagnetic urging force of the solenoid portion 60 is increased, and the set pressure difference of the first control valve CV1 is increased, accordingly. With the set pressure difference of the first control valve CV1 thus increased, the displacement of the compressor is increased. On the other hand, when the duty ratio that is commanded from the control device 68 to the driving circuit 68a is decreased, electromagnetic urging force of the solenoid portion 60 is decreased, and the set pressure difference of the first control valve CV1 is decreased. When the set pressure difference of the first control valve CV1 is decreased, the displacement of the compressor is decreased.

[0039] As shown in FIGS. 1, 3A, 4A and 4B, an accommodation hole 70 is formed in the rear housing 4 for accommodating therein the second control valve CV2. The rear housing 4 functions also as a valve housing for the second control valve CV2. In the drawings, the cross section showing the second control valve CV2 is different from that showing the first control valve CV1 and the suction chamber 21. The first control valve CV1 protrudes from a rear end 4a of the rear housing 4 toward the rear side, and the accommodation hole 70 is not covered with the first control valve CV1.

[0040] The accommodation hole 70 is formed extending through the rear end 4a and a front end of 4b of the rear housing 4 in parallel with the axis L of the drive shaft 6 or in the horizontal direction of as viewed in FIGS. 1, 3A, 4A and 4B. The front opening of the accommodation hole 70 on the front end 4b of the rear housing 4 is closed by the valve plate assembly 3. The accommodation hole 70 includes a valve chamber 71 that is a small-diameter hole, a middle-diameter hole 72 whose diameter is greater than that of the valve chamber 71, and a large-diameter hole 73 whose diameter is still greater than that of the hole 73, in this order as seen from the left side on the drawings. As seen from FIG. 3a, the valve chamber 71, the middle-diameter hole 72 and the large-diameter hole 73 are formed coaxially.

[0041] A valve hole 27a is formed in the valve plate assembly 3 that partially defines the valve chamber 71 and the cylinder block 1. The valve chamber 71 communicates with the crank chamber 5 via the valve hole 27a. The valve chamber 71 also communicates with a communication hole 27b that is formed in the rear housing 4. The communication hole 27b is opened into the valve chamber 71 through a cylindrical inner peripheral, surface 71a of the valve chamber 71. The valve hole 27a, the valve chamber 71 and the communication hole 27b form the first bleed passage 27.

[0042] A spool 75 is received in the valve chamber 71 and the middle-diameter hole 72 for movement in the horizontal direction as seen in FIGS. 1, 3A, 4A and 4B. A stopper 76 is fixedly fitted in the large-diameter hole 73. The stopper 76 is positioned by the step portion that is located between the large-diameter hole 73 and the middle-diameter hole 72 in the rear housing 4 for restricting the movement of the spool 75 beyond the rear end of the middle-diameter hole 72.

[0043] The spool 75 has a small-diameter portion 75a located on the side of the valve chamber 71 and a large-diameter portion 75b formed coaxially with the small-diameter portion 75a and located on the side of the middle-diameter portion 72. The spool 75 has also an annular-shaped movable step 78 formed between outer peripheral surfaces 77a and 77b of the small-diameter portion 75a and the large-diameter portion 75b of the spool 75. The movable step 78 includes a wall surface 78a that faces toward a side of the valve plate assembly 3.

[0044] The large-diameter portion 75b of the spool 75 has a cylindrical shape with an opening to the rear side, that is, to the side of the stopper 76. The small-diameter portion 75a of the spool 75 is almost located in the valve chamber 71, and the large-diameter portion 75b is accommodated in the middle-diameter hole 72 for movement in the axial direction of the spool 75. The small-diameter portion 75a is coaxial with the valve hole 27a, and the diameter of the small-diameter portion 75a is larger than that of the valve hole 27a. The front end of the small-diameter portion 75a forms a first valve portion 79 that adjusts the opening degree of the valve hole 27a that communicates with the valve chamber 71, that is, the opening degree of the first bleed passage 27. When the first valve portion 79 approaches the valve plate assembly 3, the opening degree of the valve hole 27a is decreased. On the other hand, when the first valve portion 79 moves away from the valve plate assembly 3, the opening degree of the valve hole 27a is increased.

[0045] A backpressure chamber 80 is defined between the stopper 76 and the large-diameter portion 75b of the spool 75 in the middle-diameter hole 72. The backpressure chamber 80 includes a cylindrical inner space of the large-diameter portion 75b. The spool 75 has a back surface 81 which includes the end surface of the opening portion of the large-diameter portion 75b and the inner bottom surface of the large-diameter portion 75b. Thus, the back surface 81 of the spool 75 is located in the backpressure chamber 80.

[0046] In the supply passage 29, a pressure introducing passage 82 branches from the supply passage 29 at the region K that is located on the side of the crank chamber 5, that is, downstream of the position of valve opening adjustment in the first control valve CV1 (or the valve seat 53). The pressure introducing passage 82 communicates with the large-diameter hole 73 and is opened into an inner peripheral surface 73a of the large diameter hole 73.

[0047] A communication groove 76a and a communication hole 76b are formed in the stopper 76 to interconnect the pressure introducing passage 82 and the middle-diameter hole 72. The communication groove 76a is formed annularly throughout the outer peripheral surface of the stopper 76 at a position facing the opening of the pressure introducing passage 82. The communication hole 76b extends through the stopper 76 between the communication groove 76a and an end surface 76c of the stopper 76 on the side of the valve plate assembly 3. The communication hole 76b is open at the center of the end surface 76c.

[0048] Pressure PdK in the region K of the supply passage 29 is introduced into the backpressure chamber 80 via the pressure introducing passage 82, the communication groove 76a and the communication hole 76b. Namely, the backpressure chamber 80 has the same pressure atmosphere as the region K that is located downstream of the position of valve opening adjustment in the control valve CV1 in the supply passage 29. Force from the pressure PdK in the backpressure chamber 80 urges the spool 75 toward the valve plate assembly 3, that is, in the direction that causes the valve to be closed. Namely, the spool 75 has the characteristics of decreasing the opening degree of the valve hole 27a with an increase in the pressure PdK in the backpressure chamber 80 that is applied to the back surface 81.

[0049] The outer diameter of the large-diameter portion 75b of the spool 75 is larger than the inner diameter of the valve chamber 71. An annular fixed step 83 is formed between the valve chamber 71 and the middle-diameter hole 72 in the second control valve CV2. The fixed step 83 includes a wall surface 83a that faces the wall surface 78a of the movable step 78 of the spool 75. When the spool 75 has reached the position closest to the valve plate assembly 3, the wall surface 78a of the movable step 78 is brought into contact with the wall surface 83a of the fixed step 83 to seat the spool 75. The axial length of the small-diameter portion 75a of the spool 75 is slightly smaller than that of the valve chamber 71. Thus, with the spool 75 positioned closest to the valve plate assembly 3, the wall surface 78a of the movable step 78 contacts the wall surface 83a of the fixed step 83, and a slight clearance is formed between the first valve portion 79 and the valve plate assembly 3. Since the first bleed passage 27 is not closed even when the opening of the valve hole 27a is reduced to the minimum and, therefore, the crank chamber 5 keeps fluid communication with the suction chamber 21 via the first bleed passage 27. The minimum opening degree of the valve hole 27a is slightly larger than zero.

[0050] The minimum clearance between the first valve portion 79 and the valve plate assembly 3 functions as a throttle of the first bleed passage 27. Thus, in consideration of the throttle of the refrigerant gas in the first bleed passage 27 when the valve hole 27a is at the minimum opening degree, the diameter of the throttle 28a of the second bleed passage 28 is set smaller than that when the second control valve CV2 and the first bleed passage 27 are not hypothetically provided.

[0051] A spring 85 such as coil spring is located in a clearance 84 between the outer peripheral surface 77a of the small-diameter portion 75a of the spool 75 and the inner peripheral surface 71 a of the valve chamber 71. The movable end of the spring 85 is in contact with the wall surface 78a of the movable step 78 at a region that is located radially inward from the region where the wall surface 78a faces the wall surface 83a of the fixed step 83. That is, the inner region of the wall surface 78a that is located radially inward from the annular region of the wall surface 78a that faces the wall surface 83a of the fixed step 83 forms a spring seat 86 for the movable end of the spring 85. The fixed end of the spring 85 is in contact with the valve plate assembly 3 at a position surrounding the opening of the valve hole 27a. The spring 85 urges the spool 75 in the direction that causes the first valve portion 79 to move so as to increases the opening degree of the valve hole 27a.

[0052] A clearance 87 is formed between an outer peripheral surface 77b of the large-diameter portion 75b of the spool 75 and an inner peripheral surface 72a of the middle-diameter hole 72, and the clearance 87 is narrower than the clearance 84 between the outer peripheral surface 77a of the small-diameter portion 75a and the inner peripheral surface 71 a of the valve chamber 71. A clearance 84a is formed between the spring 85 and the inner peripheral surface 71 a of the valve chamber 71 and, especially, is provided such that the spring 85 freely extends and contracts in accordance with the movement of the spool 75. The clearance 87 is also narrower than the clearance 84a. Namely, the clearance 87 is the narrowest of the all clearances that are around the cylindrical outer peripheral surface 77 of the spool 75.

[0053] When the wall surface 78a of the movable step 78 is moved away from the wall surface 83a of the fixed step 83 as shown in FIG. 4B, the valve chamber 71 communicates with the backpressure chamber 80 via the clearance between the wall surfaces 78a and 83a and the clearance 87 of the spool 75. On the other hand, when the wall surface 78a of the movable step 78 contacts the wall surface 83a of the fixed step 83 as shown in FIG. 3A, the communication between the backpressure chamber 80 and the valve chamber 71 via the clearance 87 of the spool 75 is shut off. Namely, the annular region of the wall surface 78a of the movable step 78 that faces the wall surface 83a of the fixed step 83 forms a second valve portion 88 for shutting off the communication between the backpressure chamber 80 and the valve chamber 71 via the clearance 87 of the spool 75. A valve seat 89 for the second valve portion 88 is formed by an annular region of the wall surface 83a of the fixed step 83 that faces the second valve portion 88.

[0054] As shown in FIGS. 1 and 2, a filter 90 is arranged in the supply passage 29 on the side of the discharge chamber 22, that is, upstream of the first control valve CV1 for removing foreign substances in the refrigerant gas. As shown in FIGS. 3A and 4, the width of the clearance 87 between the large-diameter portion 75b of the spool 75 and the inner peripheral surface 72a of the accommodation hole 70 is larger than the diameter of the foreign substances that pass through the filter 90. In other words, the width of the clearance 87 is larger than the diameter of the mesh openings of the filter 90. Namely, the clearance 87 that is the narrowest clearance around the cylindrical outer peripheral surface 77 of the spool 75 is formed with a width that is larger than the diameter of the foreign substances flowing through the clearance 87.

[0055] Referring to FIG. 3B, in the second control valve CV2, the cross sectional area of the valve chamber 71 that is perpendicular to the axial direction of the spool 75 is represented as SA, and the cross sectional area of the valve hole 27a that is also perpendicular to the axial direction of the spool 75 is represented as SB, which is smaller than SA. A force for urging the spool 75 toward the valve plate assembly 3, that is, in the direction in which the opening degree of the valve hole 27a is decreased in response to the varying pressure difference between the pressure PdK and the crank pressure Pc is expressed by "(PdK - Pc) SB".

[0056] A force for urging the spool 75 in the direction which causes the opening degree of the valve hole 27a to be decreased in accordance with the pressure difference between the pressure PdK and the suction pressure Ps, is expressed by "(PdK - Ps) (SA - SB)." The urging force of the spring 85 is represented as "f." Conditional inequality (1) for the minimum opening degree of the valve hole 27a in the second control valve CV2 is expressed as follows:

$$(PdK-Ps)(SA-SB) + (Pdk-Pc)\,SB > f \qquad (1)$$

[0057] The backpressure chamber 80 is in constant communication with the crank chamber 5 via the supply passage 29 and has the same pressure atmosphere as the crank chamber 5. Thus, it is presumed that the pressure PdK is substantially the same as the pressure Pc. Therefore, the above inequality (1) is expressed as the following conditional inequality (2):

$$(Pc- Ps)\,(SA -SB) > f \qquad (2)$$

[0058] The spring 85 for use in the illustrated embodiment has a small set load and a low spring constant. It is understood, therefore, from the above conditional inequality (2) that the valve portion 79 reduces the opening degree of the valve hole 27a to the minimum opening degree when the crank pressure Pc somewhat exceeds the suction pressure Ps.

[0059] When a predetermined length of time or more has passed after a stop of the vehicle engine E, the pressure is equalized at a low value in the refrigerant circulation circuit and, therefore, the crank pressure Pc becomes substantially the same as the suction pressure Ps. Since the conditional inequality (2) is no more effective, the spool 75 is moved by the urging force of the spring 85 until the spool 75 is brought into contact with the stopper 76, as shown in FIG. 4A. With the spool 75 thus fully urged by the spring 85, the valve portion 79 sets the opening degree of the valve hole 27a at its maximum.

[0060] In a conventional compressor for a vehicle air-conditioner, liquid refrigerant, existing on the low pressure side of the external refrigerant circuit 30 with the vehicle engine E kept at a stop for a long time, flows into the crank chamber 5 via the suction chamber 21 due to the fluid communication between the crank chamber 5 and the suction chamber 21 via the first and second bleed passages 27 and 28. Especially, when the temperature in the engine room where the compressor is located is lower than that in the vehicle interior, a large amount of the liquid refrigerant flows into the crank chamber 5 via the suction chamber 21 and is accumulated in the crank chamber 5. Therefore, when the vehicle engine E is started and the compressor is also started thereby through the clutchless type power transmission mechanism PT, the liquid refrigerant evaporates under the influence of heat generated by the vehicle engine E and also of the stirring effect due to stirring the liquid refrigerant by the swash plate 12, with the result that the crank pressure Pc tends to be increased regardless the opening degree of the valve hole 27a.

[0061] For example, when the vehicle engine E is started while the vehicle interior is hot, the control device 68 is operated in response to the cooling demand from the occupant of the vehicle to command maximum duty ratio to the drive circuit 68a, and the set pressure difference of the first control valve CV1 is set at the maximum value for performing cooling as required. Accordingly, the first control valve CV1 closes the supply passage 29, and no high pressure refrigerant gas is supplied from the discharge chamber 22 to the crank chamber 5 and the backpressure chamber 80 of the second control valve CV2. Therefore, even if evaporation of the liquid refrigerant occurs in the crank chamber 5, the state where the pressure difference between the crank pressure Pc and the suction pressure Ps does not exceed the urging force f, that is, the state where the conditional inequality (2) is not effective, continues.

[0062] Consequently, the spool 75 of the second control valve CV2 is maintained in such a state that the first valve portion 79 fully opens the first bleed passage 27 by the urging force f of the urging spring 85, and the liquid refrigerant in the crank chamber 5, as well as the refrigerant gas evaporated from a part of the liquid refrigerant, is immediately flown into the suction chamber 21 via the fully-opened first bleed passage 27. Thus, the crank pressure Pc is maintained at a low value corresponding to that the first control valve CV1 is closed, the compressor increases the inclination angle of the swash plate 12 thereby to increase the displacement of the compressor to its maximum.

[0063] If the first control valve CV1 remains closed even after the liquid refrigerant is flown out from the crank chamber 5, the first bleed passage 27 is fully opened by the first valve portion 79 of the second control valve CV2 as described above. Thus, even if the amount of blow-by gas from the cylinder bores 1a to the crank chamber 5 is more than the amount initially designed, for example, due to worn pistons 20, the blow-by gas is immediately flown into the suction chamber 21 via the first and second bleed passages 27 and 28. Therefore, the crank pressure Pc is maintained at substantially the same level as the suction pressure Ps, and the maximum inclination angle of the swash plate 12, that is, the maximum displacement operation (100% displacement operation) of the compressor is maintained.

[0064] As described above, when the first valve portion 79 of the second control valve CV2 sets the opening degree of the first bleed passage 27 larger than the minimum opening degree, the second valve portion 88 is moved away from the valve seat 89, and the backpressure chamber 80 communicates with the valve chamber 71 via the clearance 87 (refer to FIG. 4B). However, since the first control valve CV1 is in its closed state when the backpressure chamber 80 is in communication with the valve chamber 71, no refrigerant gas in the discharge chamber 22 flows into the backpressure chamber 80 via the first control valve CV1, and hence there is no fear of a decrease in efficiency of the refrigerant cycle caused by leakage of the refrigerant gas from the backpressure chamber 80 to the valve chamber 71.

[0065] When the vehicle interior is cooled to a certain extent due to the above maximum displacement operation of the compressor, the control device 68 reduces the duty ratio that is commanded to the drive circuit 68a from the maximum. Accordingly, the first control valve CV1 is changed from the closed state and opens the supply passage 29 so that the crank pressure Pc becomes higher than the suction pressure Ps. The conditional inequality (2) is satisfied, so that spool 75 moves against the urging force of the spring 85 in the direction to reduce the valve opening and the first bleed passage 27, that is, the valve hole 27a is substantially throttled by the first valve portion 79.

[0066] Namely, when the supply passage 29 is opened by the first control valve CV1 and the introduction of the refrigerant gas from the discharge chamber 22 into the crank chamber 5 starts, the amount of the refrigerant gas flown out from the crank chamber 5 to the suction chamber 21 via the first bleed passage 27 is substantially decreased in accordance with the above gas introduction into the crank chamber 5. Thus, the crank pressure Pc is rapidly increased, and the compressor immediately reduces the inclination angle of the swash plate 12 so that the displacement of the compressor is reduced.

[0067] Amount of the compressed refrigerant gas that leaks from the discharge chamber 22 to the crank chamber 5 further to the suction chamber 21 is reduced by decreasing the opening degree of the first bleed passage 27 by the second control valve CV2, so that the decrease in the efficiency of the refrigerant cycle is prevented. Furthermore, although the refrigerant circulation circuit in the first preferred embodiment is formed such that the refrigerant circulation stops by operating the compressor at the minimum displacement (so called an OFF operation of the clutchless compressor), the OFF operation of the compressor is reliably performed due to the substantial decrease in the opening degree of the first bleed passage 27 by the second control valve CV2.

[0068] When the first valve portion 79 of the second control valve CV2 sets the first bleed passage 27 at the minimum opening degree, the second valve portion 88 contacts the valve seat 89 as described above. Accordingly, the communication between the valve chamber 71 and the backpressure chamber 80 is shut off. Thus, the refrigerant gas in the discharge chamber 22 is prevented from leaking from the backpressure chamber 80 to the suction chamber 21 via the clearance 87, the valve chamber 71 and the communication hole 27b. Therefore, the decrease in the efficiency of the refrigerant cycle is prevented.

[0069] While the first control valve CV1 is opened, fine foreign substances that are not removed by the filter 90 flow into the second control valve CV2 together with the refrigerant gas and possibly further into the clearance 87 of the spool 75. However, since the width of the clearance 87 of the spool 75 is larger than the diameter of the foreign substances that have passed through the filter 90, the foreign substances are prevented from being caught in the clearance 87, so that the spool 75 moves smoothly without any operation failure. Even if the foreign substances remain in the clearance 87 at the second valve portion 88 in contact with the valve seat 89, such foreign substances are removed from the clearance 87 by the flow of the refrigerant gas occurring when the second control valve CV2 is opened as shown in FIG. 4B.

[0070] The following advantageous effects are obtained according to the above-described first preferred embodiment of the present invention.

(1) When the first valve portion 79 sets the valve hole 27a at the minimum opening degree, the second valve portion 88 of the spool 75 shuts off the communication between the backpressure chamber 80 and the valve chamber 71 via the clearance 87 of the spool 75 in the second control valve CV2. Thus, it is unnecessary that the clearance 87 is set small, and the operation failure of the spool 75 caused by the foreign substances caught in the clearance 87 is prevented.

(2) The second valve portion 88 is formed by the wall surface 78a of the movable step 78 on the cylindrical outer peripheral surface 77 of the spool 75, and the valve seat 89 for the second valve portion 88 is formed by the wall surface 83a of the fixed step 83. In other words, the functions of the second valve portion 88 and the valve seat 89 are provided to the second control valve CV2 by simple structure such as the movable and fixed steps 78 and 83 In the first preferred embodiment. Therefore, the structure of the second control valve CV2 is simplified.

(3) The minimum opening degree of the valve hole 27a by the first valve portion 79 of the second control valve CV2 is not zero. Thus, it is not necessary to machine the first valve portion 79 and the second valve portion 88 in the spool 75 at a very high accuracy, and the manufacture of the spool 75 is easier. Accordingly, in a structure in which the valve portions 79 and 88 provided in the spool 75 are required to be brought into contact simultaneously with the valve plate assembly 3 and the valve seat 89 so as to shut off the fluid communication and, parts of the control valve are required to be manufactured to a very high standard of accuracy. Apparently, the structure will make it troublesome and hence costly to manufacture valve parts such as spool, valve seat and valve plate assembly.

(4) The second control valve CV2 includes the spring 85 for urging the spool 75 in the direction to increase the valve opening, and the urging force f of the spring 85 relates to the positioning of the spool 75. Thus, the operating characteristics of the second control valve CV2 is easily adjusted by changing the urging force f of the spring 85, that is, by selecting an appropriate spring from a group of springs having different characteristics.

(5) In the second control valve CV2, the wall surface 78a of the movable step 78 that forms the second valve portion 88 is also utilized as the spring seat 86 for the spring 85. Accordingly, in comparison to a case in which a spring seat (a step) is provided separately from the movable step 78, the structure of the spool 75 and the structure of the second control valve CV2 is simplified.

(6) The filter 90 is provided between the discharge chamber 22 and the first control valve CV1, and the width of the clearance 87 of the spool 75 is larger than the diameter of the foreign substances that pass through the filter 90. Thus, the foreign substances whose diameter is larger than the width of the clearance 87 of the spool 75 will not be caught in the clearance 87, and the operation failure of the spool 75 in the second control valve CV2 is prevented successfully.

The following will describe a second preferred embodiment according to the present invention. In the following description about the second preferred embodiment, only the difference thereof from the first preferred embodiment will be described. Like or corresponding elements or parts are referred to by like reference numerals, and the detailed description thereof is omitted.

The valve hole 27a of the above-described first preferred embodiment is arranged so as to interconnects the crank chamber 5 and the valve chamber 71. However, the valve hole 27a in the second preferred embodiment is arranged so as to interconnects the suction chamber 21 and the valve chamber 71 as shown in FIGS. 5 and 6. Further, the communication hole 27b, which is arranged so as to interconnect the suction chamber 21 and the valve chamber 71 in the above-described first preferred embodiment, is modified in the second preferred embodiment such that the communication hole 27b interconnects the crank chamber 5 and the valve chamber 71.

The accommodation hole 70 of the second control valve CV2 extends in the vertical direction in FIGS. 5 and 6 and is open to the outside of the compressor. The valve chamber 71 is located in the upper side of the accommodation hole 70, the large-diameter hole 73 is located in the lower side of the accommodation hole 70, and the middle-diameter hole 72 is removed from the accommodation hole 70.

The valve hole 27a is open in a ceiling surface 71 b of the valve chamber 71. The communication hole 27b is open in the inner peripheral surface 71 a of the valve chamber 71. The communication hole 27b serves as a part of the region of the supply passage 29 on the side of the crank chamber 5 with respect to the second control valve CV2. The connection in the supply passage 29 between the first and second control valves CV1 and CV2 is open in the Inner peripheral surface 73a of the large-diameter hole 73 of the second control valve CV2.

A spool 91 having a cylindrical shape with a cover is accommodated in the valve chamber 71 for movement in the vertical direction as seen in FIGS. 5 and 6. The spool 91 is placed so as to have its opening that faces downward. The diameter of the top surface of the cylindrical spool 91 is larger than that of the valve hole 27a. A region of the top surface of the spool 91 that faces the ceiling surface 71 b of the valve chamber 71 forms a valve portion 92. A region of the ceiling surface 71 b of the valve chamber 71 that faces the valve portion 92 forms a valve seat 93 for the valve portion 92.

The spool 91 is formed with a flange 94 protruding radially outwardly from the opening portion of the spool 91. A cylindrical outer peripheral surface 77 of the spool 91 includes an outer peripheral surface 77a of the flange 94 and an outer peripheral surface 77b of the cylindrical portion that is located above the flange 94 in the spool 91 as seen in FIGS. 5 and 6. The spool 91 inserts into the spring 85 that is located in the clearance 84 formed between the outer peripheral surface 77b of the spool 91 and the inner peripheral surface 71a of the valve chamber 71. The upper surface of the flange 94 forms the spring seat 86 for receiving the movable end of the spring 85. A region on the ceiling surface 71 b outward from the valve seat 93 forms a spring seat for receiving the fixed end of the spring 85.

A slope 91a is formed in the lower peripheral surface of the flange 94. The slope 91a is formed such that the distance from its sloped surface to the end surface 76c of the stopper 76 is increasing as the diameter of the slope 91 a is larger. The back surface 81 of the spool 91 includes the inner ceiling surface of the spool 91, the lower surface of the spool 91 and the slope 91 a of the spool 91. The back surface 81 is located in the backpressure chamber 80. Although the valve chamber 71 and the backpressure chamber 80 in the second preferred embodiment are in constant communication with each other and share the same space, a region adjacent to the back surface 81 of the spool 91 is referred to as the backpressure chamber 80. The backpressure chamber 80 has the same pressure atmosphere as the region K that is located downstream of the position of valve opening adjustment (the valve seat 53) of the first control valve CV1 in the supply passage 29.

In the second control valve CV2, the clearance 87 between the outer peripheral surface 77a of the flange 94 and the inner peripheral surface 71 a of the valve chamber 71 is narrower than the clearance 84 between the spring 85 and the inner peripheral surface 71 a of the valve chamber 71. The width of the clearance 87 is larger than the diameter of the foreign substances that are around the cylindrical outer peripheral surface 77 of the spool 91 and pass through the filter 90.

It is presumed that the pressure PdK in the backpressure chamber 80 is substantially the same as the crank pressure Pc. Thus, the spool 91 closes the valve hole 27a in such a manner that the valve portion 92 contacts the valve seat 93 when the conditional inequality (3) below is satisfied. Therefore, when the crank pressure Pc somewhat exceeds the suction pressure Ps, the second control valve CV2 closes the first bleed passage 27. In the conditional inequality (3), the weight of the spool 91 is ignored, and "SB" denotes the cross sectional area of the valve hole 27a.

$$(Pc - Ps)\ SB > f \qquad (3)$$

With the first control valve CV1 opened, the crank pressure Pc is increased, so that the above conditional inequality (3) is effective. Thus, the spool 91 is moved upward until the valve portion 92 contacts the valve seat 93, so that the valve hole 27a or the first bleed passage 27 is closed, as shown in FIG. 5. The constant communication between the crank chamber 5 and the suction chamber 21 is ensured by the second bleed passage 28.

The communication hole 27b partially forms the supply passage 29 together with the valve chamber 71 and the backpressure chamber 80. Thus, the refrigerant gas that flows into the backpressure chamber 80 via the first control valve CV1 flows into the crank chamber 5 via the valve chamber 71 and the communication hole 27b. The refrigerant gas flowing into the valve chamber 71 is guided by the slope 91a of the spool 91 so as to flow smoothly into the communication hole 27b.

When the valve portion 92 of the spool 91 closes the valve hole 27a, the communication between the backpressure chamber 80 and the valve hole 27a via the clearance 87 of the spool 91 is shut off simultaneously by the valve portion 92. Thus, the refrigerant gas in the discharge chamber 22 is prevented from leaking from the region K to the suction chamber 21 via the backpressure chamber 80, the valve chamber 71 and the valve hole 27a, so that the decrease in the efficiency of the refrigerant cycle is prevented.

When the first control valve CV1 is closed, that is, when the supply passage 29 is closed, as shown in FIG. 6, the crank pressure Pc is lowered, and the above conditional inequality (3) is no more effective, so that the spool 91 moves downward and the valve portion 92 moves away from the valve seat 93. Thus, the valve hole 27a communicates with the communication hole 27b via the valve chamber 71, and the first bleed passage 27 is wide opened. Therefore, the refrigerant in the crank chamber 5 is immediately flown out into the suction chamber 21.

The following advantageous effects are obtained according to the second preferred embodiment.

(7) In the second control valve CV2, the valve portion 92 of the spool 91 closes the valve hole 27a or the first bleed passage 27 and also simultaneously shuts off of the communication between the backpressure chamber 80 and the valve hole 27a via the clearance 87 of the spool 91. Thus, it is unnecessary that the clearance 87 is set to be small, and the operation failure of the spool 91 caused by foreign substances caught in the clearance 87 is prevented.

(8) The first bleed passage 27 and the supply passage 29 share the communication hole 27b as a common part of the passages. Namely, the communication hole 27b serves as the part of the first bleed passage 27 and the supply passage 29 between the crank chamber 5 and the valve chamber 71. Thus, since a part of the supply passage 29 between the branch point of the pressure introducing passage 82 and the crank chamber 5 in the first preferred embodiment is removed from the supply passage 29, the arrangement of the passages is simplified, and the structure of the displacement control mechanism is simplified.

[0071] Now, a third preferred embodiment will be described with reference to FIGS. 7 and 8. The third preferred embodiment differs from the second preferred embodiment mainly in that the second control valve CV2 is installed in the valve housing 45 of the first control valve CV1. In the first control valve CV1 in the third preferred embodiment, the relationship of upstream or downstream between the ports 51 and 52 is reverse of the relationship in the first control valve CV1 of FIG. 2. That is, the supply passage 29 is connected at the upstream side thereof (or the side of the discharge chamber 22) to the port 52 and at the downstream side thereof (or the side of the crank chamber 5) to the port 51.

[0072] A spool 96, a valve seat body 97 and the spring 85 of the second control valve CV2 are accommodated in the valve accommodation chamber 46 of the first control valve CV1. A through hole 96a is formed in the middle of the spool 96. The valve rod 40 is inserted into the through hole 96a, and the spool 96 moves in the axial direction of the valve rod 40. The valve seat body 97 is located below the spool 96 and in contact with the fixed core 62 in the valve accommodation chamber 46. The part of the valve accommodation chamber 46 located above the top surface of the valve seat body 97 forms the valve chamber 71. A recess 96b is formed on the top surface of the spool 96 around the through hole 96a.

[0073] A port 98 is formed in the peripheral wall of the valve housing 45 that surrounds the lower portion of the valve accommodation chamber 46. The port 98 is connected to the first bleed passage 27 on the side of the suction chamber 21. The valve hole 27a is formed in the valve seat body 97 and interconnects the port 98 and the valve chamber 71. The valve hole 27a is open at the top surface of the valve seat body 97 between the inner peripheral surface and the outer peripheral surface of the valve seat body 97. A groove 96c is formed in the lower surface of the spool 96. The groove 96c has an annular shape surrounding the through hole 96a and has a part that faces the valve hole 27a of the valve seat body 97.

[0074] An annular region in the lower surface of the spool 96 that is located radially outward of the groove 96c forms the valve portion 92. An annular region in the top surface of the valve seat body 97 that is located radially outward of the valve hole 27a and faces the valve portion 92 forms the valve seat 93 for the valve portion 92.

[0075] An annular region in the lower surface of the spool 96 that is located radially inward of the groove 96c forms a valve portion 96d for the through hole 96a. An annual region in the top surface of the valve seat body 97 that is located radially inward of the valve hole 27a and faces the valve portion 96d forms the valve seat 97a for the valve portion 96d. With the valve portion 92 brought in contact with the valve seat 93, the valve portion 96d contacts the valve seat 97a, thereby shutting off the communication between the valve hole 27a and the backpressure chamber 80 via the clearance formed between the inner peripheral surface of the of the through hole 96a of the spool 96 and the outer peripheral Surface of the guide rod 44 in the valve rod 40.

[0076] A flange 94 is formed at the top of the spool 96. The lower surface of the flange 94 forms the spring seat 86 for receiving the movable end of the spring 85. A region in the top surface of the valve seat body 97 that is located radially outward of the valve seat 93 forms the valve seat for receiving the fixed end of the urging spring 85. The back surface 81 of the spool 96 is formed by the top surface of the spool 96 and the bottom surface of the recess 96b. The backpressure chamber 80 that is located between the back surface 81 and the position of valve opening adjustment, or the valve seat 53, of the first control valve CV1 forms a part of the region K that is located downstream, that is, on the side of the crank chamber 5, of the position of valve opening adjustment of the first control valve CV1 in the supply passage 29. Namely, the backpressure chamber 80 has the same pressure atmosphere as the region K.

[0077] The cylindrical outer peripheral surface 77 of the spool 96 includes the outer peripheral surface 77a of the flange 94 and the outer peripheral surface of the spool 96 that is located below the flange 94. The spring 85 is located in the clearance 84 between the outer peripheral surface 77b and the inner peripheral surface 71a of the valve chamber 71. The clearance 87 between the outer peripheral surface 77a of the flange 94 and the inner peripheral surface 71 a of the valve chamber 71 is narrower than the clearance 84a between the spring 85 and the inner peripheral surface 71 a of the valve chamber 71.

[0078] As shown in FIG. 7, with the first control valve CV1 opened, the crank pressure Pc, which is considered to be substantially the same as the pressure PdK in the backpressure chamber 80, is increased, so that the spool 96 is moved downward until the valve portion 92 contacts the valve seat 93. Thus, the valve hole 27a is closed and the first bleed passage 27 is closed, accordingly. Thus, the refrigerant gas that flows from the discharge chamber 22 into the backpressure chamber 80 via the port 52 and the communication passage 47 flows into the crank chamber 5 via the port 51.

[0079] As shown in FIG. 8, with the first control valve CV1 closed, that is, when the supply passage 29 is closed, on the other hand, the crank pressure Pc is decreased. Accordingly, the spool 96 is moved upward by the urging force of the spring 85, that is, the valve portion 92 is moved away from the valve seat 93, so that the valve hole 27a communicates with the port 51 and the first bleed passage 27 is wide opened. Thus, the refrigerant in the crank chamber 5 is immediately flown into the suction chamber 21 via the port 51, the valve chamber 71 and the valve hole 27a.

[0080] According to the third preferred embodiment, the same advantageous effects are obtained as those which have been described in the second preferred embodiment. In addition, since the first and second control valves CV1 and CV2 are formed as a single unit, the first and second control valves CV1 and CV2 are easily assembled to the rear housing 4 during manufacturing of the compressor.

[0081] The preferred embodiment according to the present invention is not limited to the above-described preferred embodiments, but it may be modified in various ways as follows.

[0082] A first alternative embodiment is shown in FIG. 9 and is a modification of the second preferred embodiment. In this embodiment, the spool 91 is formed in the top surface thereof with a recess 91 b. A cross sectional area SC of the recess 91 b that is perpendicular to the axis of the spool 91 is larger than the cross sectional area SB of the valve hole 27a that is perpendicular to the axis of the spool 91. In the conditional inequality (3) for closing the valve hole 27a, the pressure difference (Pc - Ps) is multiplied by the cross sectional area SC of the recess 91 b instead of the cross sectional area SB of the valve hole 27a. Thus, even if the urging force f of the spring 85 is set relatively large with respect to a predetermined value of the pressure difference (Pc - Ps), the second control valve CV2 closes.

[0083] As described above, when the air-conditioner is started, it is desirable that the valve hole 27a is wide opened for allowing the liquid refrigerant that is accumulated in the crank chamber 5 to flow out thereof. However, when the air-conditioner is stated, the refrigerant gas in the suction chamber 21 is drawn into the cylinder bores 1a and the suction pressure Ps is instantaneously decreased, so that the spool 91 of the second control valve CV2 may be moved toward the valve hole 27a thereby to decrease the opening degree of the valve hole 27a. In the result, the efficiency of flowing the liquid refrigerant is decreased. Thus, a relatively large amount of the urging force of the spring 85 that acts on the spool 91 in the direction which increases the opening degree of the valve hole 27a is required. Therefore, the embodiment of FIG. 9, wherein the spool 91 is formed in the top surface thereof with the recess 91 b, prevents a decrease in the efficiency of flowing the liquid refrigerant, while ensuring the ease of closing operation of the second control valve CV2.

[0084] Furthermore, in the first alternative embodiment shown in FIG. 9, the communication hole 27b extends obliquely upward from the valve chamber 71. There is a large space in the valve chamber 71 and the large-diameter hole 73 on the side of the communication hole 27b. A wall 99 protrudes from the stopper 76 in the vertical direction as seen on the drawing to the ceiling surface 71 b of the valve chamber 71. The wall 99 divides the valve chamber 71 into a space that accommodates the spool 91 and a communication passage 100 that extends in the vertical direction on the drawing and communicates with the communication hole 27b.

[0085] A hole 99a is formed through the wall 99 so that the refrigerant gas that flows from the first control valve CV1 into the backpressure chamber 80 via the communication hole 76b of the stopper 76 and is guided toward the wall 99 by the slope 91 c flows toward the crank chamber 5 via the communication passage 100 and the communication hole 27b. In addition to the hole 99a, another hole 99b is formed through the wall 99 so that, when the second control valve CV2 is opened, the refrigerant that flows from the crank chamber 5 into the communication passage 100 via the communication hole 27b flows into the' suction chamber 21 via the valve chamber 71 and the valve hole 27a. The hole 99b is formed above the hole 99a. Even though the communication hole 27b extends obliquely upward from the valve chamber 71, the provision of the communication passage 100 and the though holes 99a and 99b helps to facilitate the flow of the refrigerant gas in the first bleed passage 27 and the supply passage 29.

[0086] A second alternative embodiment that is a modification of the second preferred embodiment is shown in FIG. 10. This alternative embodiment differs from the second preferred embodiment in that the spool 91 is disposed in upside down relation, the flange 94 is removed, and the spring 85 is accommodated within the spool 91. In this case, the inner and outer diameters of the spool 91 are enlarged by the length of the removed flange 94 for the valve chamber 71 having the same diameter as in the second preferred embodiment. In the second alternative embodiment of FIG. 10, above conditional inequality (3) is used in such a way that the pressure difference (Pc - Ps) is multiplied, not by the cross sectional area SB of the valve hole 27a, but by a cross sectional area SD of the inner space of the spool 91 that is perpendicular to the axis of the spool 91 and is larger than the cross sectional area SC of the recess 91 b of the spool 91 having the flange 94 as shown in FIG. 9. Therefore, the second alternative embodiment of FIG. 10 prevents a decrease in the efficiency of flowing the liquid refrigerant, while ensuring the ease of closing operation of the second control valve CV2.

[0087] In the second alternative embodiment shown in FIG. 10, if the slope 91 c is further formed in the inner periphery and at the open end of the spool 91, in the above conditional inequality (3), the pressure difference (Pc - Ps) is multiplied by a cross sectional area SE of the opening of the spool 91 that is perpendicular to the axis of the spool 91 and is larger than the cross sectional area SD of the inner space of the spool 91 that is located below the slope 91c. Therefore, the second alternative embodiment of FIG. 10 prevents a decrease in the efficiency of flowing the liquid refrigerant, while ensuring the ease of closing operation of the second control valve CV2.

[0088] In the first preferred embodiment, the minimum opening degree of the valve hole 27a by the first valve portion 79 of the second control valve CV2 is not zero. However, it is so arranged, as shown in FIGS. 11 through 14, that the minimum opening degree of the valve hole 27a by the first valve portion 79 is zero and also that elasticity is provided to at least one of the first valve portion 79, the valve seat or the valve plate assembly 3 for the first valve portion 79, the second valve portion 88 and the valve seat 89 for the second valve portion 88. In this case, the element provided with the elasticity out of the above-named parts is elastically deformable. By so arranging, the opening of the two valve portions 79 and 88 formed in the single spool 75 can be reduced to zero simultaneously without the need of machining the spool 75 and the valve seat 89 (or the valve plate assembly 3) at a very high accuracy.

[0089] In a third alternative embodiment shown in FIG. 11, the second valve portion 88 of the second control valve CV2 is formed by a ring-shaped lead 101. The small-diameter portion 75a has an engaging protrusion 75c, and the large-diameter portion 75b has an engaging recess 75d. In the spool 75, the large-diameter portion 75b and the small-diameter portion 75a are combined together such that the engaging protrusion 75c is inserted into the engaging recess 75d with the lead 101 held between the small-diameter portion 75a and the large-diameter portion 75b. A slope 78b is formed in the region of the wall surface 78a of the movable step 78 and is located outside the spring seat 86 for allowing the lead 101 to be deformed toward a space provided by forming the slope 78b.

[0090] In a fourth alternative embodiment shown in FIG. 12, the first valve portion 79 of the second control valve CV2 is formed by a lead 102. The lead 102 has a ring shape and is fitted around a protrusion 75e formed at the center of the end surface of the small-diameter portion 75a on the side thereof adjacent to the valve plate assembly 3. A slope 75f is formed on the end surface of the small-diameter portion 75a in the radially outward region thereof for the same purpose as the slope 78b of FIG. 11.

[0091] Furthermore, in a fifth alternative embodiment shown in FIG. 13, the large-diameter portion 75b of the spool 75, that is, the second valve portion 88 is made of rubber. As a further alternative embodiment of the fifth alternative embodiment, the small-diameter portion 75a, instead of the large-diameter portion 75b (the second valve portion 88), of the spool 75 is made of rubber.

[0092] A sixth alternative embodiment that is a modification of the fifth alternative embodiment is shown in FIG. 14. In this embodiment, the large-diameter portion 75b is fitted in a cylinder 103 that is made of metal. The width of the clearance 87 between the outer peripheral surface of the cylinder 103 and the inner peripheral surface 72a of the middle-diameter hole 72 is larger than the diameter of the foreign substances that pass through the filter 90. The second valve portion 88 is formed protruding beyond the cylinder 103.

[0093] In this embodiment, even though the rubber large-diameter portion 75b is deformed when the rubber large-diameter portion 75b contacts the valve seat 89 or the stopper 76, the cylinder 103 functions to restrict the deformation of the rubber large-diameter portion 75b in the radially outward direction. Thus, the clearance 87 is formed without considering the deformation of the rubber large-diameter portion 75b.

[0094] Also, the foreign substances are less liable to be attached to the surface of the metallic cylinder 103 than to the surface of rubber. Even if the foreign substances are accumulated in the clearance 87 when the second valve portion 88 contacts the valve seat 89, such foreign substances are easily flown from the clearance 87 by the refrigerant gas when the second valve portion 88 is moved away from the valve seat 89. Additionally, since the outer peripheral surface of the metallic cylinder 103 is less susceptible to damage by the foreign substances, the endurance of the spool 75 is extended.

[0095] In addition to the third through sixth alternative embodiments shown in FIGS. 11 through 14, for example, the entire spool 75 is made of rubber to provide elasticity to both the first and second valve portions 79 and 88. Also, the valve seat for the first valve portion 79 is formed by a lead or rubber to be provided with elasticity. Furthermore, the valve seat 89 for the second valve portion 88 is formed by a lead or rubber for the same purpose. In still further alternative embodiment, elasticity is provided to both the valve seat for the first valve portion 79 and the valve seat 89 for the second valve portion 88.

[0096] In the above-described first and second preferred embodiments, the backpressure chamber 80 of the second control valve CV2 has the same pressure atmosphere as the region K that is located downstream of the position of valve opening adjustment (the valve seat 53) of the first control valve CV1 in the supply passage 29, and the backpressure chamber 80 is in constant communication with the crank chamber 5 via the part of the supply passage 29. However, in a seventh alternative embodiment, a passage that interconnects the backpressure chamber 80 and the crank chamber 5 is provided independently of the supply passage 29. Namely, the backpressure chamber 80 has the same pressure atmosphere via the above passage and the crank chamber 5 as the region K that is located downstream of the position of valve opening adjustment (the valve seat 53) in the supply passage 29.

[0097] In each of the above-described preferred embodiments, the backpressure chamber 80 of the second control valve CV2 is in constant communication with the crank chamber 5 via the part of the supply passage 29, and it is presumed that the pressure PdK in the backpressure chamber 80 is substantially the same as the crank pressure Pc. However, in an eighth alternative embodiment, a fixed throttle is formed in the valve plate assembly 3 on the supply passage 29, so that the pressure PdK in the backpressure chamber 80 is larger than the crank pressure Pc when the first control vale CV1 is opened.

[0098] In this modification, when decreasing the displacement of the compressor in a state in which the second control valve CV2 is opened, the pressure PdK in the backpressure chamber 80 is rapidly increased by opening the first control valve CV1, so that the second control valve CV2 is closed. Thus, the displacement of the compressor is immediately decreased.

[0099] In each of the above-described preferred embodiments, the first control valve CV1 is so constructed that the pressure difference (PdH - PdL) is detected between the pressure monitoring points P1 and P2. However, the first control valve CV1 is so constructed that only the suction pressure Ps is detected in a ninth alternative embodiment. Namely, the first control valve CV1 is constructed to internally autonomously position the valve rod 40 in response to the variation of the suction pressure Ps such that a control target or a set suction pressure for the suction pressure Ps that is determined by the electromagnetic urging force of the solenoid 60 is maintained.

[0100] Although the spring 85 of the second control valve CV2 is provided by a coil spring in the above-described preferred embodiments, the spring 85 includes a plate spring in a tenth alternative embodiment.

[0101] In an eleventh alternative embodiment, the spring 85 in each of the above-described preferred embodiments is removed from the second control valve CV2. However, the provision of the spring 85 in the second control valve CV2 is desired because such spring assists in smooth opening of the valve hole 27a and it is preferable that the spring 85 is provided for stabilizing the operation of the second control valve CV2.

[0102] In a twelfth alternative embodiment, the second bleed passage 28 in the above-described first preferred embodiment is removed. In a thirteenth alternative embodiment, clutch mechanism such as an electromagnetic clutch is utilized as the power transmission mechanism PT.

[0103] In a fourteenth alternative embodiment, the present invention is applied to a wobble plate type variable displacement compressor.

[0104] 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 of the appended claims.

Claims

1. A displacement control mechanism used in a variable displacement compressor for controlling a displacement of the compressor, the compressor partially forming a refrigerant circulation circuit of an air-conditioner, the displacement of the compressor being varied in accordance with a pressure in a crank chamber of the compressor, the refrigerant circulation circuit including a suction pressure region and a discharge pressure region, a first bleed passage interconnecting the crank chamber and the suction pressure region, a supply passage interconnecting the crank chamber and the discharge pressure region, a first control valve located on the supply passage for controlling an opening degree of the supply passage, a second control valve located on the first bleed passage, the second control valve including, a backpressure chamber having substantially the same pressure atmosphere as a region of the supply passage downstream of the first control valve, a spool including a back surface that is located in the backpressure chamber and a cylindrical outer peripheral surface, the spool reducing an opening degree of the first bleed passage when a pressure in the backpressure chamber that is applied to the back surface is increased, **characterized in that** the spool blocks a communication between the backpressure chamber and the first bleed passage via a clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve when the spool sets the first bleed passage at a minimum opening degree.

2. The displacement control mechanism according to claim 1, wherein the second control valve further including:

   a valve chamber partially forming the first bleed passage and communicating with the suction pressure region;
   a valve hole partially forming the first bleed passage and interconnecting the valve chamber

and the crank chamber, wherein the spool further includes a first valve portion located in the valve chamber, the spool having a cylindrical outer peripheral surface, wherein the first valve portion reduces an opening degree of the valve hole when a pressure in the backpressure chamber that is applied to the back surface is increased, wherein a second valve portion is formed in the spool to block a communication between the backpressure chamber and the valve chamber via the clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve when the first valve portion sets the valve hole at a minimum opening degree.

3. The displacement control mechanism according to claim 2, wherein an annular movable step is provided in the cylindrical outer peripheral surface of the spool, the movable step including a movable wall surface that faces toward a side of the valve hole and forms the second valve portion, an annular fixed step being provided in the second control valve, the fixed step including a fixed wall surface that faces the movable wall surface and forms a valve seat for the second valve portion, the communication between the backpressure chamber and the valve chamber being blocked by contacting the movable wall surface with the fixed wall surface.

4. The displacement control mechanism according to claim 3, wherein a spring is located In the valve chamber for urging the spool in a direction that increases the opening degree of the valve hole, the movable wall surface including an inner region that is located radially inwardly from an annular region of movable wall surface that forms the second valve portion, the inner region forming a spring seat for the spring.

5. The displacement control mechanism according to any one of claims 2 through 4, further comprising a filter located in the supply passage between the discharge pressure region and the first control valve for removing foreign substances in refrigerant gas, a width of the clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve is larger than a diameter of the foreign substances that pass through the filter.

6. The displacement control mechanism according to any one of claims 2 through 5, wherein the minimum opening degree of the valve hole by the first valve portion is slightly larger than zero.

7. The displacement control mechanism according to any one of claims 2 through 6, wherein the minimum opening degree of the valve hole by the first vale portion is zero, elasticity being provided to at least one of the first valve portion, a valve seat for the first valve portion, the second valve portion and a valve seat for the second valve portion, the displacement control mechanism further comprising a second bleed passage that interconnects the crank chamber and the suction pressure region and includes a fixed throttle.

8. The displacement control mechanism according to claim 7, wherein at least one of the first valve portion and the second valve portion is formed by a ring-shaped lead.

9. The displacement control mechanism according to any one of claims 7 and 8, wherein the one of the first valve portion and the second valve portion is made of rubber.

10. The displacement control mechanism according to any one of claims 7 through 9, wherein the spool includes a large-diameter portion that forms the movable wall surface, the large-diameter portion being fitted in a metallic cylinder.

11. The displacement control mechanism according to claim 1, further comprising a second bleed passage interconnecting the crank chamber and the suction pressure region, the second bleed passage having a fixed throttle, wherein the second control valve further includes:

a valve chamber partially forming the first bleed passage and communicating with the crank chamber;
a valve hole partially forming the first bleed passage and interconnecting the valve chamber and the suction pressure region, wherein the spool further includes a valve portion located in the valve chamber, the spool having a cylindrical outer peripheral surface, wherein the valve portion closes the valve hole when a pressure in the backpressure chamber that is applied to the back surface is increased, wherein the valve portion simultaneously blocks a communication between the backpressure chamber and the valve chamber via the clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve when the valve portion closes the valve hole.

12. The displacement control mechanism according to claim 11, further comprising a filter located in the supply passage between the discharge pressure region and the first control valve for removing foreign substances in refrigerant gas, a width of the clearance formed around the cylindrical outer peripheral surface of the spool in the second control valve is larger than a diameter of the foreign substances that pass through the filter.

13. The displacement control mechanism according to any one of claims 11 and 12, wherein the first bleed passage and the supply passage share a common passage between the crank chamber and the valve chamber.

14. The displacement control mechanism according to any one of claims 11 through 13, wherein the second control valve is installed in the first control valve.

15. The displacement control mechanism according to any one of claims 11 through 13, wherein a recess is formed on a surface of the spool that faces the valve hole, the recess having a cross section that is larger than that of the valve hole.

16. The displacement control mechanism according to any one of claims 11 through 13, wherein a spool has a cylindrical shape with an opening that is open to the valve hole, a spring being located in the spool for urging the spool in a direction in which an opening degree of the valve hole is increased.

FIG. 1

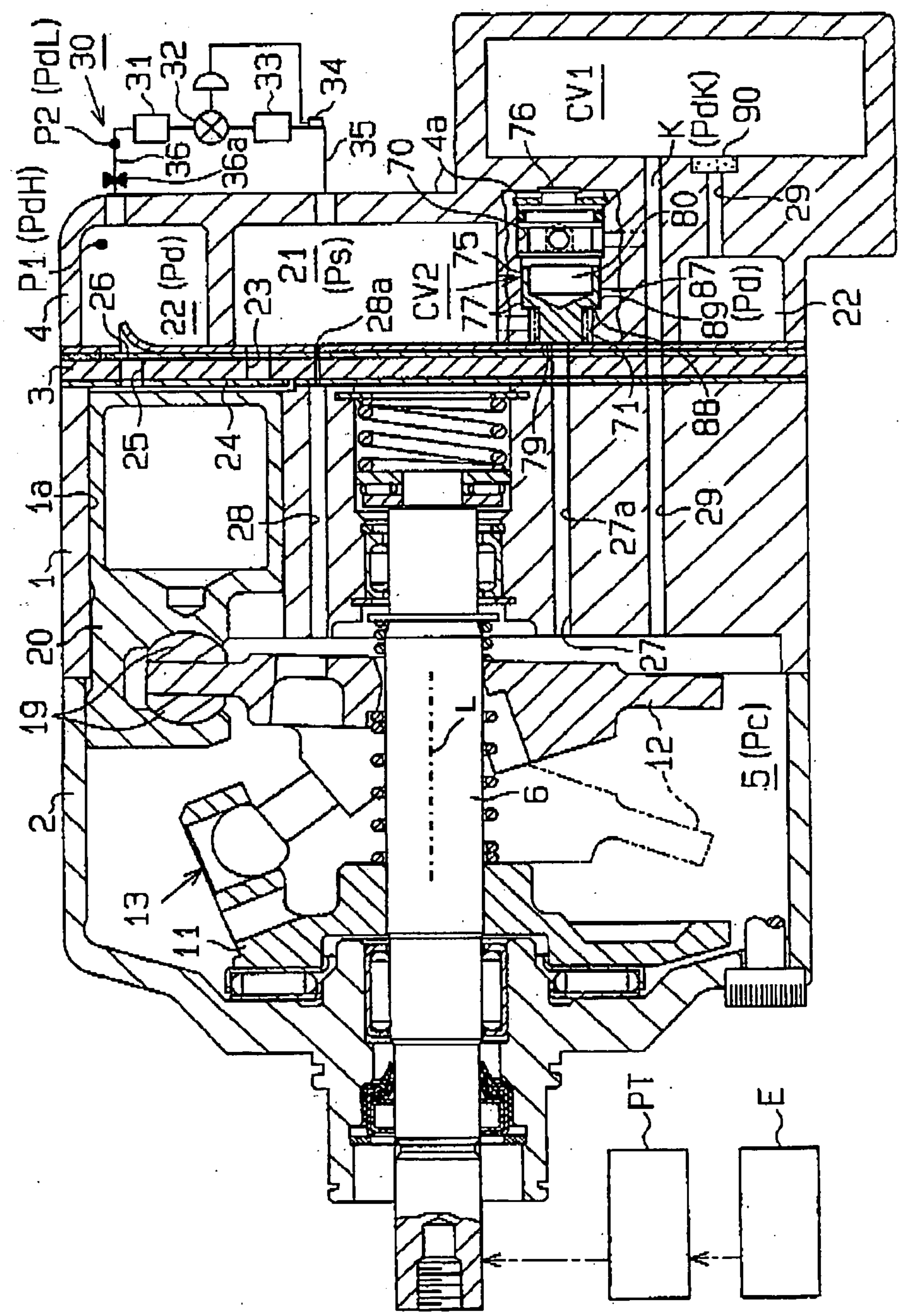
P1 (PdH)
P2 (PdL)
30
31
32
33
34
35
36
36a
70
4a
76
CV1
K
(PdK)
90
29
4
26
22 (Pd)
23
21
(Ps)
28a
CV2
75
77
80
87
89
(Pd)
22
3
25
24
79
71
88
1a
28
27a
29
1
20
27
19
L
12
5 (Pc)
2
6
13
11
PT
E

FIG. 2

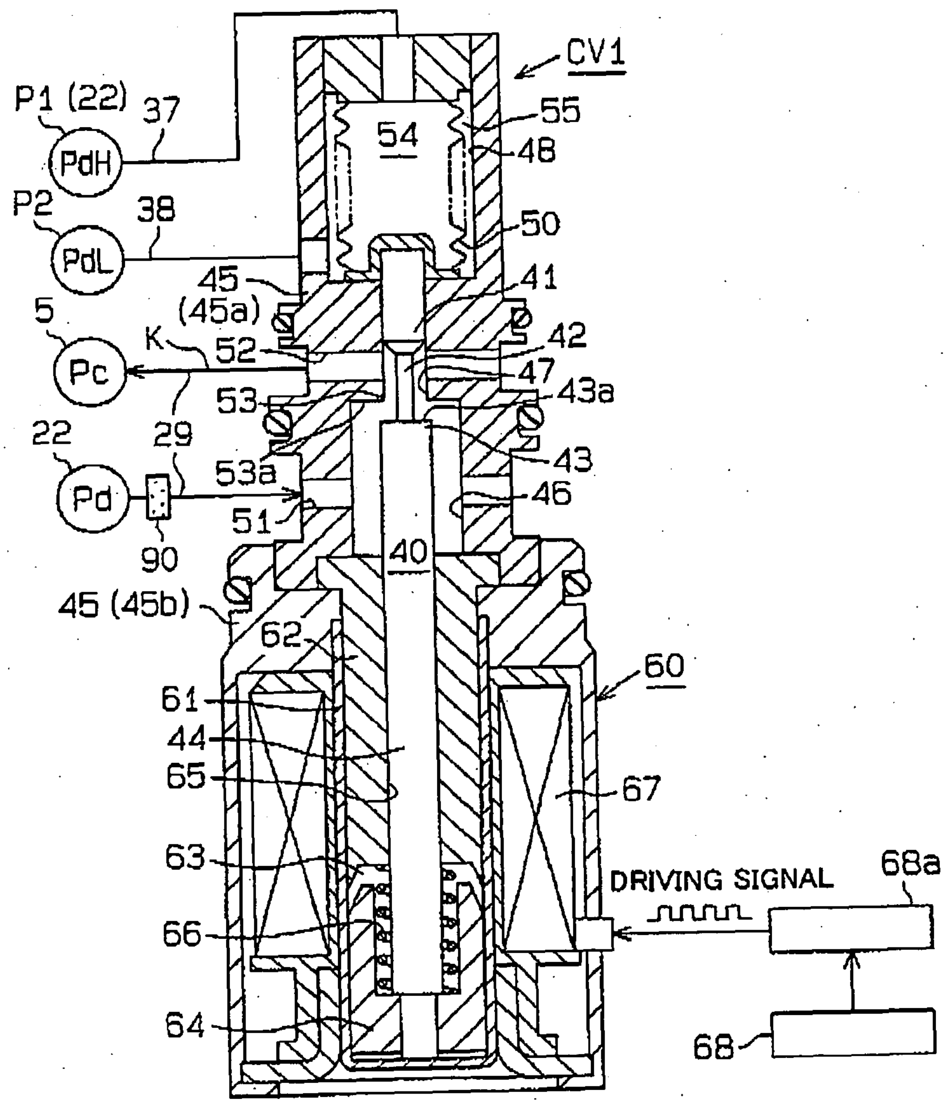
CV1
P1 (22)
37
PdH
55
54
48
P2
38
PdL
50
45
(45a)
41
5
K
52
42
Pc
47
43a
53
22
29
43
53a
Pd
46
51
90
40
45 (45b)
62
60
61
44
65
67
63
DRIVING SIGNAL
68a
66
64
68

FIG. 3A

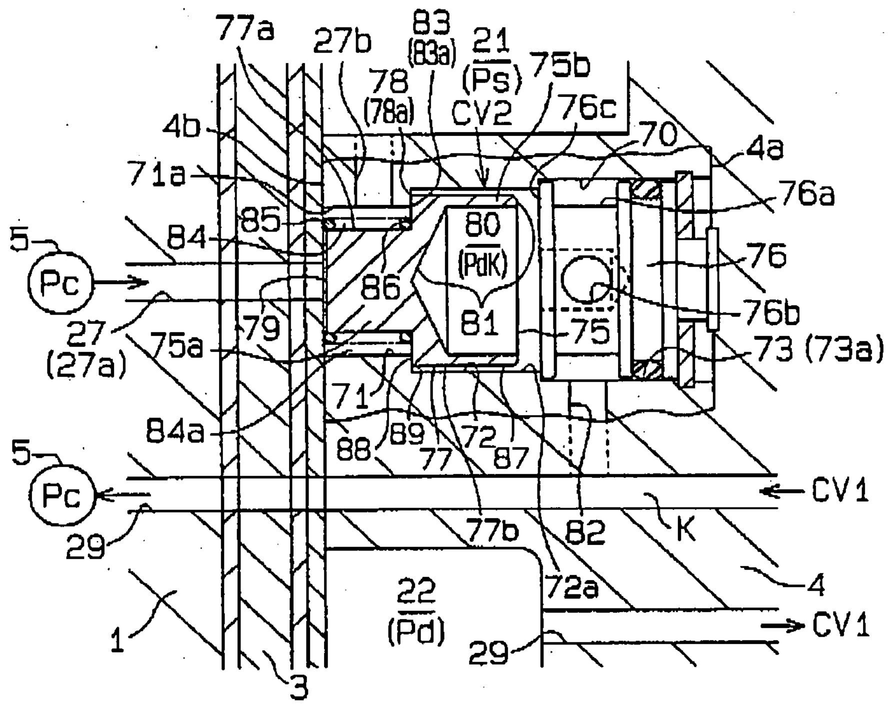
77a
27b
83
(83a)
21
(Ps)
75b
78
(78a)
CV2
76c
70
4a
4b
71a
76a
5
Pc
85
84
80
(PdK)
76
86
27
(27a)
79
76b
81
75
75a
73 (73a)
71
84a
88
89
77
72
87
CV1
29
77b
82
K
4
72a
22
(Pd)
1
3

FIG. 3B

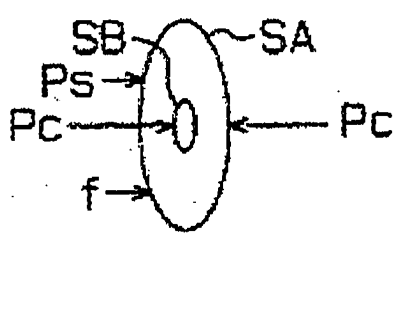
SB
SA
Ps
Pc
Pc
f

FIG. 4A

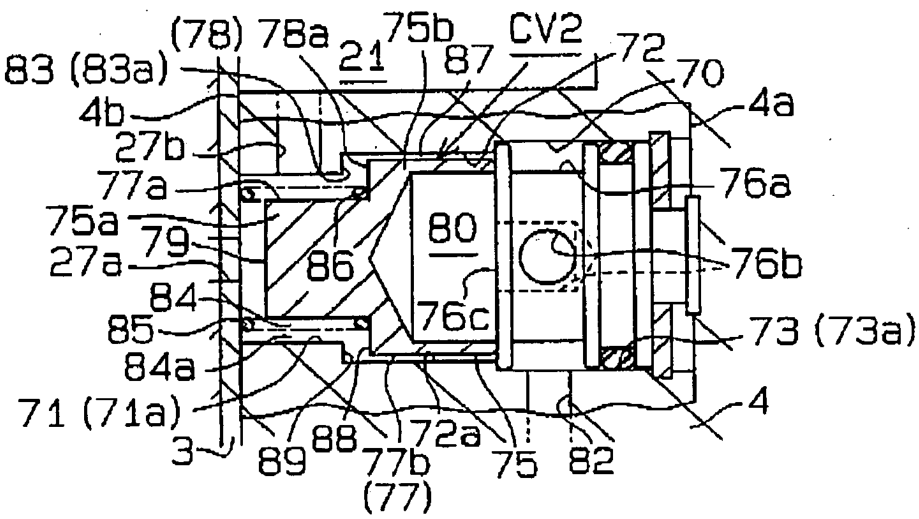
(78)
78a
75b
21
CV2
87
72
70
83 (83a)
4b
4a
27b
77a
76a
75a
79
80
27a
86
76b
84
76c
85
73 (73a)
84a
71 (71a)
4
3
89
88
77b
(77)
72a
75
82

FIG. 4B

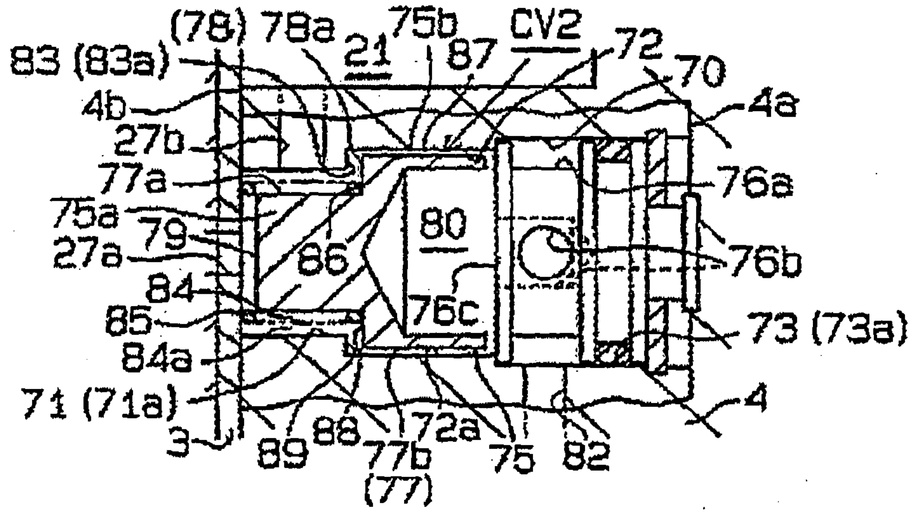
(78)
78a
21
75b
CV2
87
72
70
83 (83a)
4b
4a
27b
77a
76a
75a
79
80
27a
86
76b
84
76c
85
73 (73a)
84a
71 (71a)
4
3
89
88
77b
(77)
72a
75
82

FIG. 5

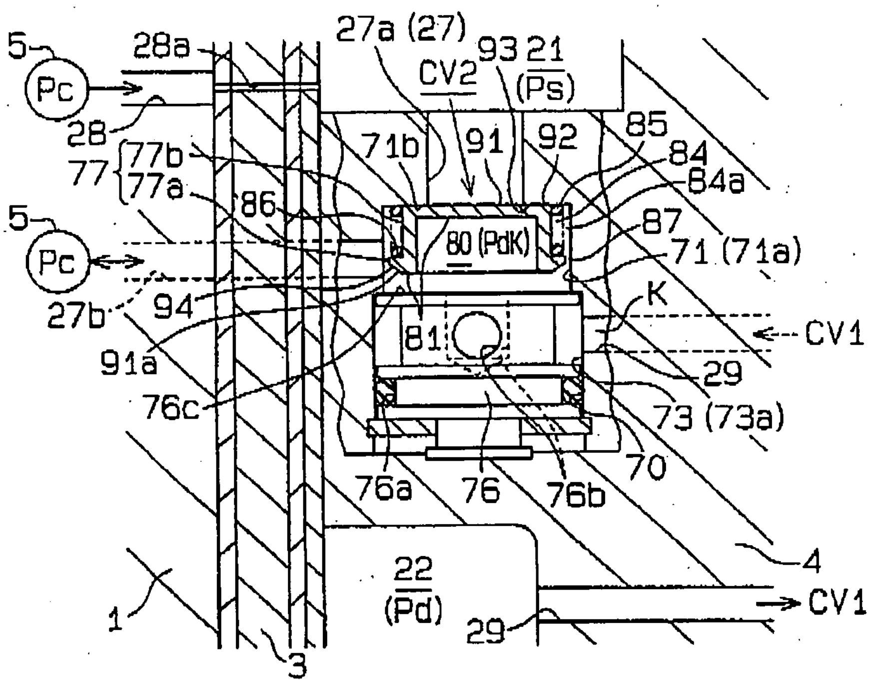
5
Pc
28a
28
77
77b
77a
86
27a (27)
CV2
93
21
(Ps)
71b
91
92
85
84
84a
80 (PdK)
87
71 (71a)
27b
94
91a
76c
81
K
CV1
29
73 (73a)
70
76a
76
76b
4
22
(Pd)
1
3

FIG. 6

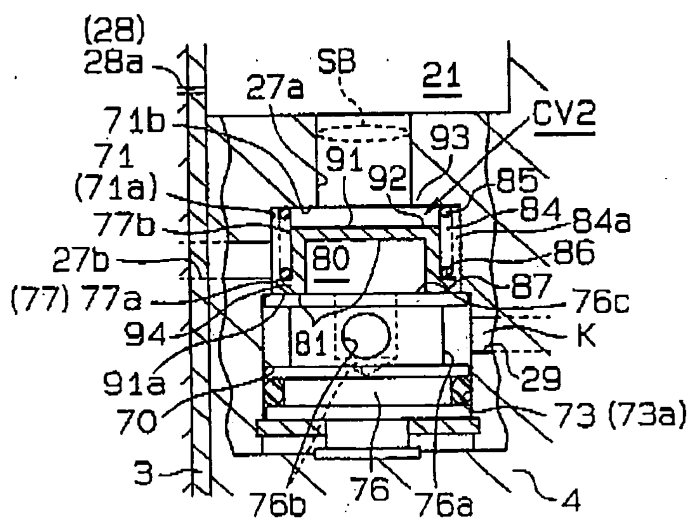
(28)
28a
SB
21
27a
71b
71
(71a)
77b
27b
(77) 77a
94
91a
70
3
CV2
93
91
92
85
84
84a
86
80
87
76c
81
K
29
73 (73a)
76b
76
76a
4

FIG. 7

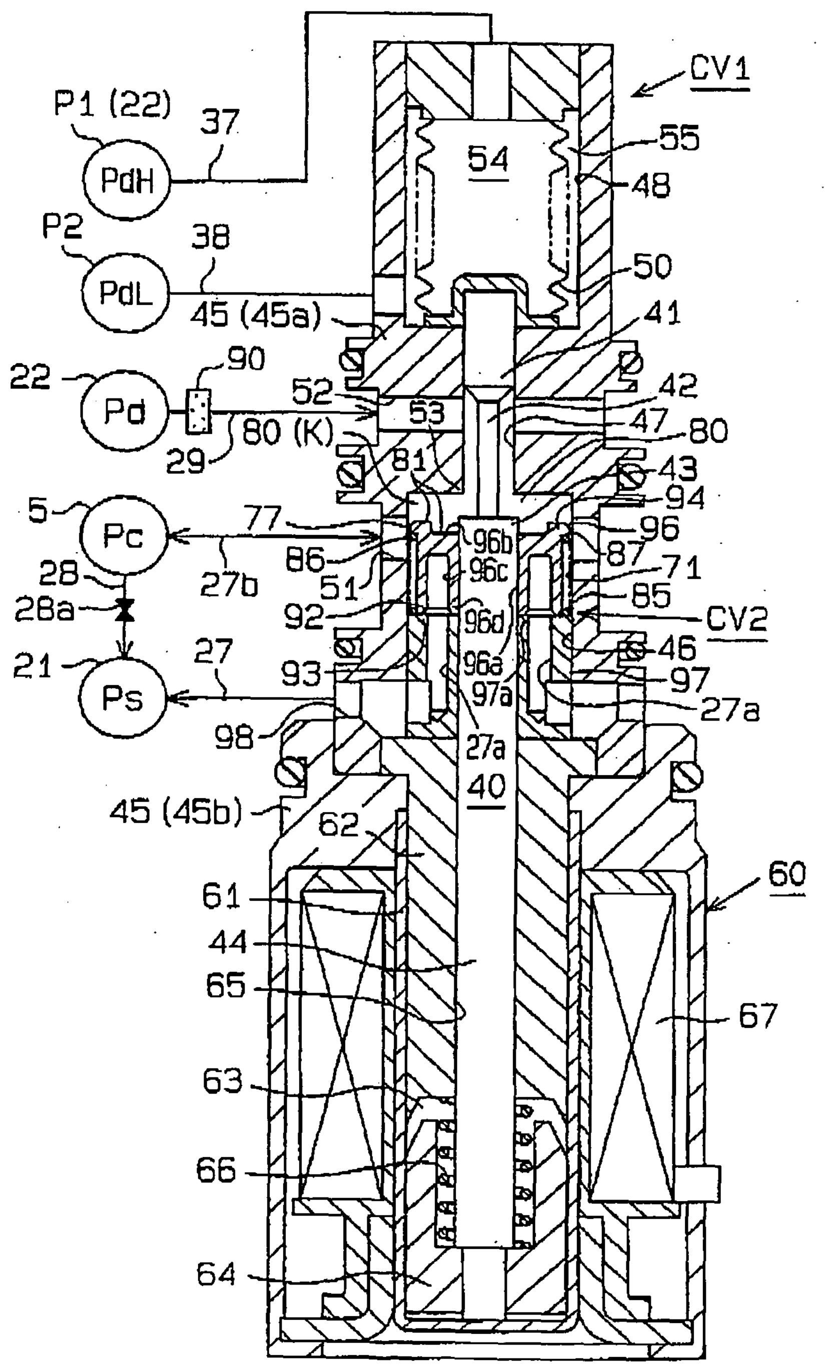
CV1
P1 (22)
37
PdH
55
54
48
P2
38
PdL
50
45 (45a)
41
22
Pd
90
52
42
53
47
80
29
80 (K)
81
43
94
5
Pc
77
96b
96
86
96c
87
71
28
27b
51
85
28a
92
96d
CV2
93
96a
46
21
Ps
27
97a
97
27a
98
27a
40
45 (45b)
62
60
61
44
65
67
63
66
64

FIG. 8

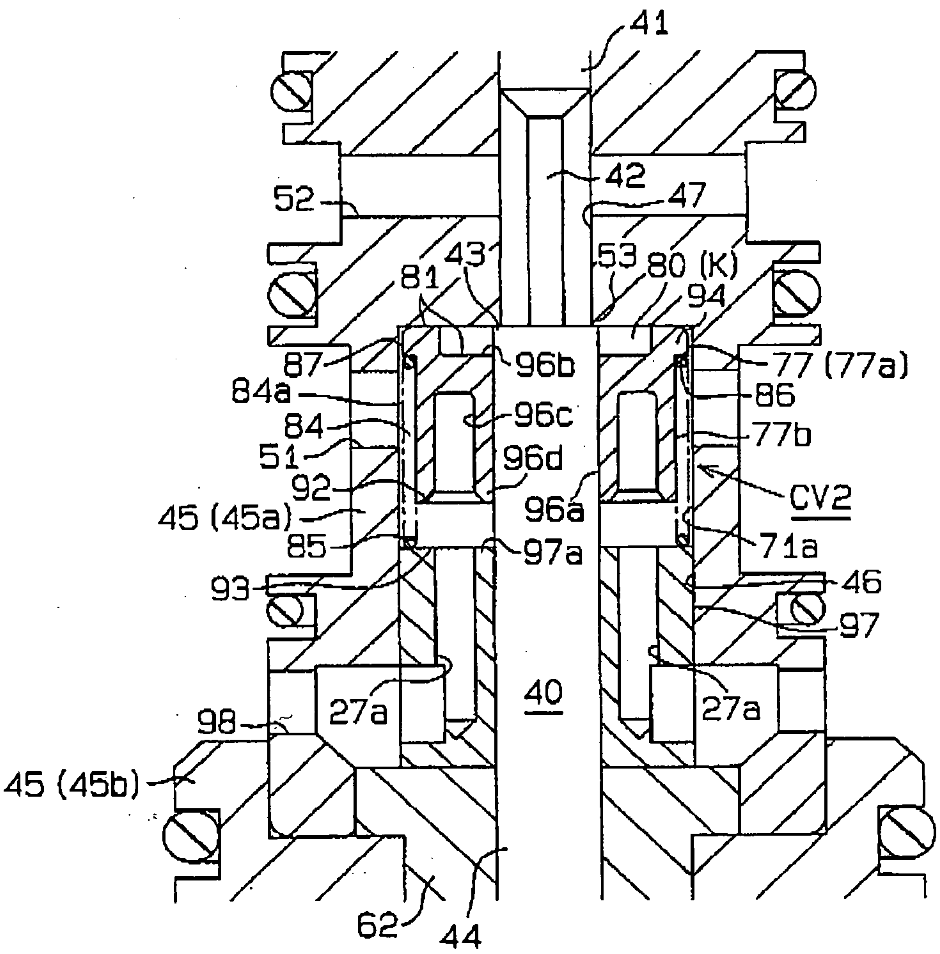
41
42
47
52
43
53
80 (K)
81
94
87
96b
77 (77a)
84a
86
84
96c
77b
51
96d
92
96a
CV2
45 (45a)
85
97a
71a
93
46
97
98
27a
40
27a
45 (45b)
62
44

FIG. 9

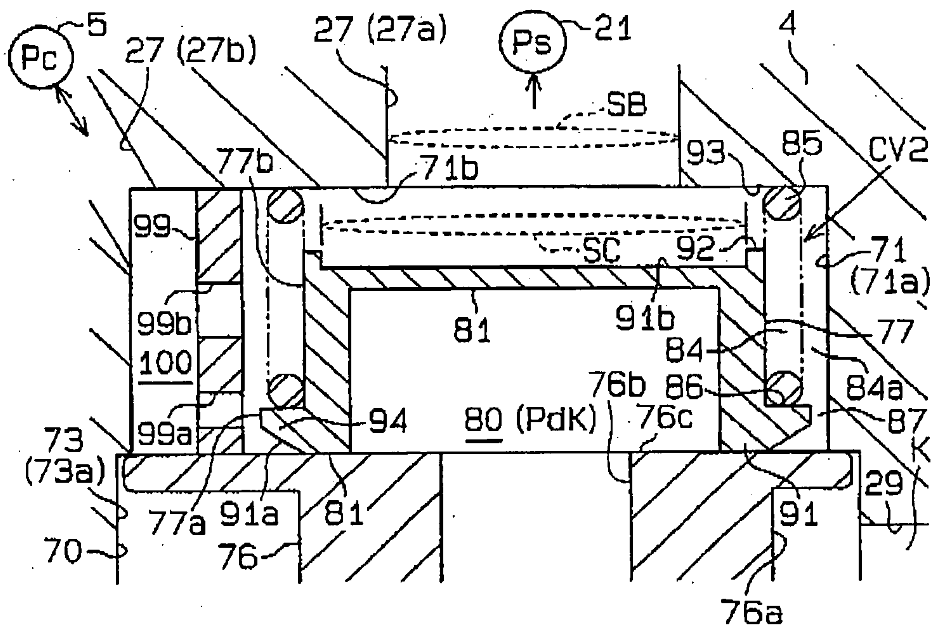
Pc
5
27 (27b)
27 (27a)
Ps
21
4
SB
77b
71b
93
85
CV2
99
SC
92
71
(71a)
99b
81
91b
77
100
84
84a
76b
86
99a
94
80 (PdK)
76c
87
73
(73a)
K
29
77a
91a
81
91
70
76
76a

FIG. 10

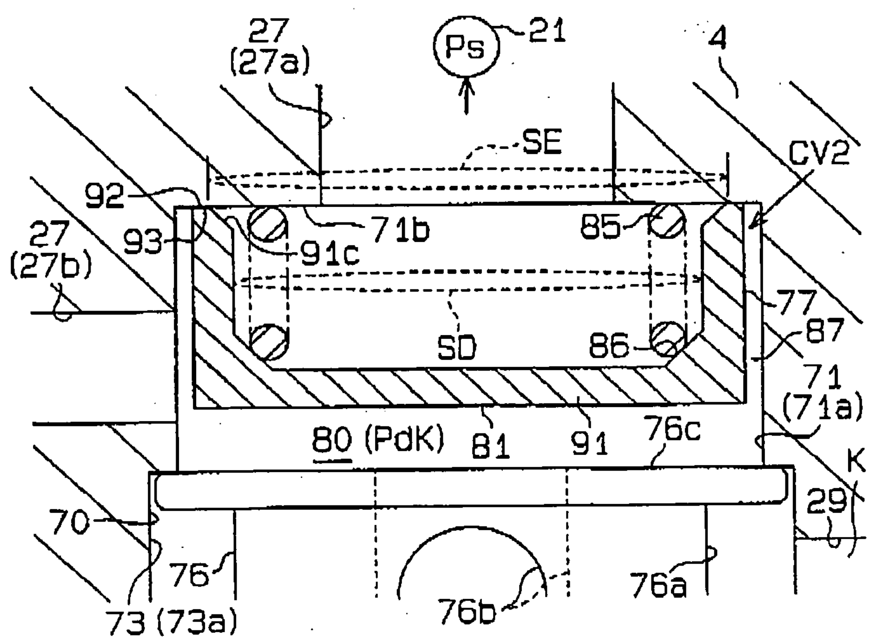
27
(27a)
Ps
21
4
SE
CV2
92
71b
85
27
93
91c
(27b)
77
SD
86
87
71
(71a)
80 (PdK)
81
91
76c
K
29
70
76
76a
76b
73 (73a)

FIG. 11

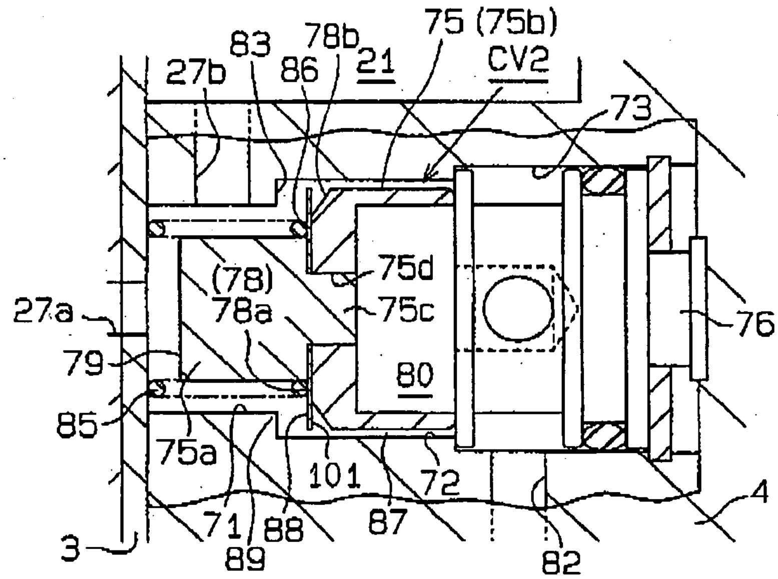
27b
83
86
78b
21
75 (75b)
CV2
73
(78)
78a
75d
75c
27a
79
80
76
85
75a
101
72
4
71
88
87
89
82
3

FIG. 12

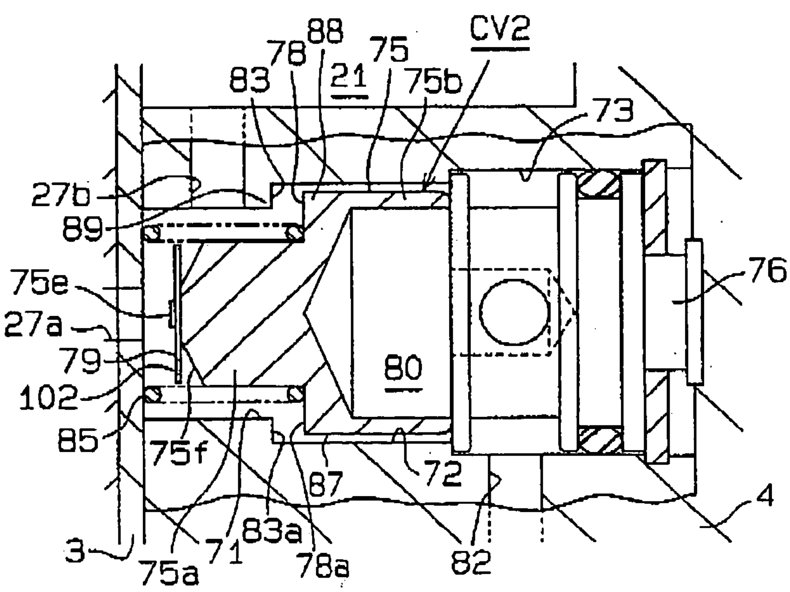
83
78
88
21
75
75b
CV2
73
27b
89
75e
27a
79
102
85
80
76
75f
87
72
4
83a
71
75a
78a
82
3

FIG. 13

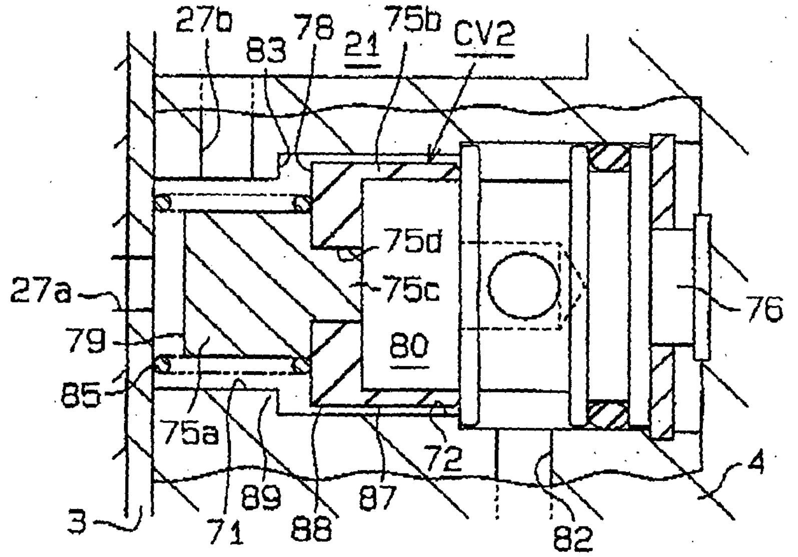
27b
78
75b
CV2
83
21
75d
75c
27a
76
79
80
85
75a
72
4
89
87
3
71
88
82

FIG. 14

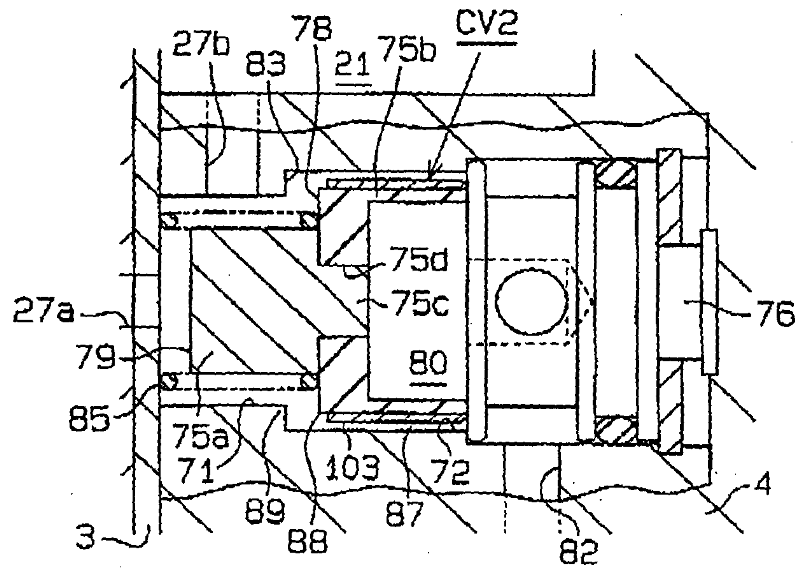
78
CV2
27b
75b
83
21
75d
75c
27a
76
79
80
85
75a
71
103
72
4
89
87
3
88
82

FIG. 15 (PRIOR ART)

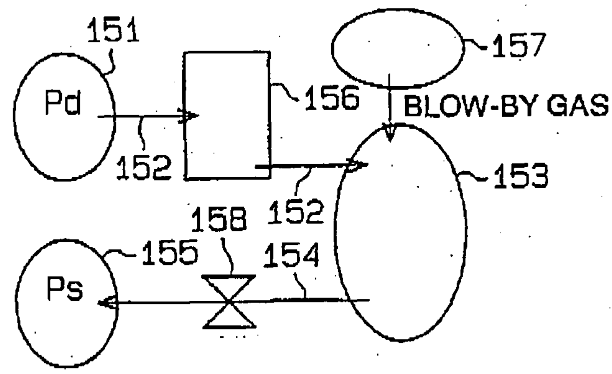

FIG. 16 (PRIOR ART)