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(54) CONTROL VALVE FOR VARIABLE DISPLACEMENT COMPRESSOR

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(57) **ABSTRACT**

A control valve is configured such that as a position of a high pressure-side valve body positioned by a solenoid is closer to one side, a degree of opening for communication of a high pressure valve portion is more widened and a pressure on the side of a discharge flow path acting on the high pressure-side valve body is weakened. Further, the control valve is configured such that as a position of a low pressure-side valve body positioned by the solenoid is closer to the other side, a degree of opening for communication of a low pressure valve portion is more widened. When the high pressure-side valve body and the low pressure-side valve body are integrally positioned on the one side by the solenoid and the low pressure-side valve body is positioned on the other side by the solenoid, the high pressure-side valve body and the low pressure-side valve body are separated from each other.

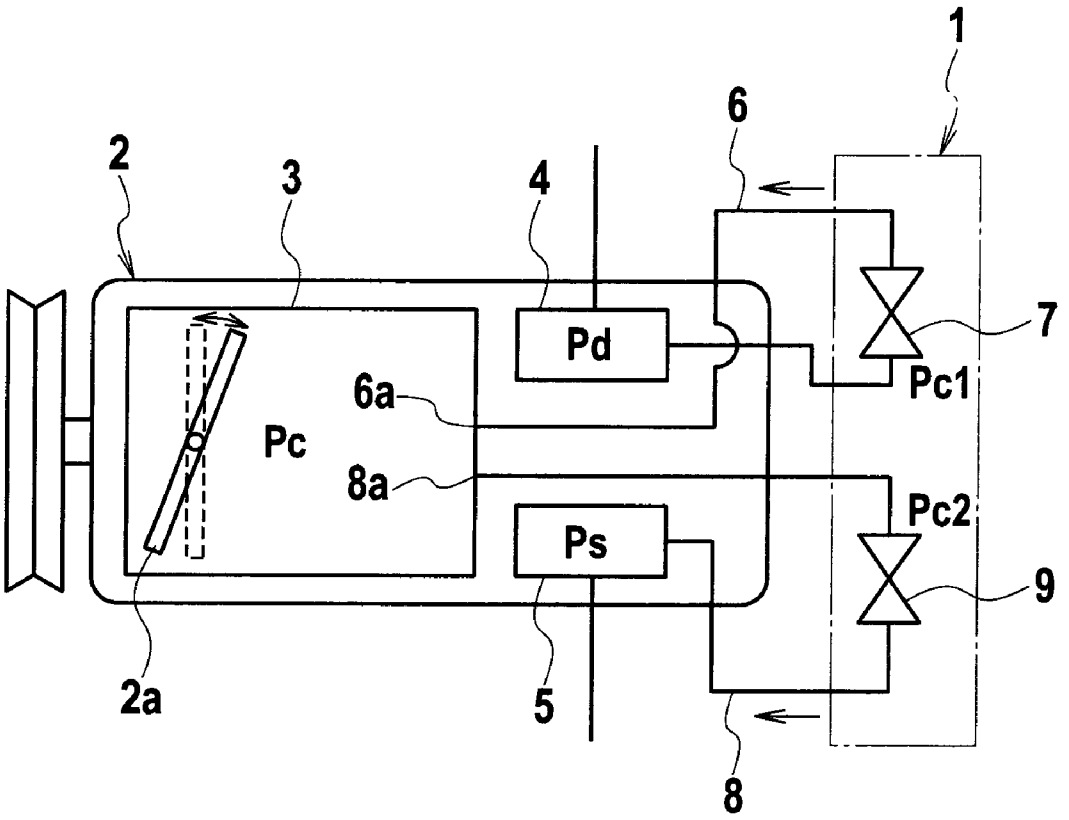


FIG. 1

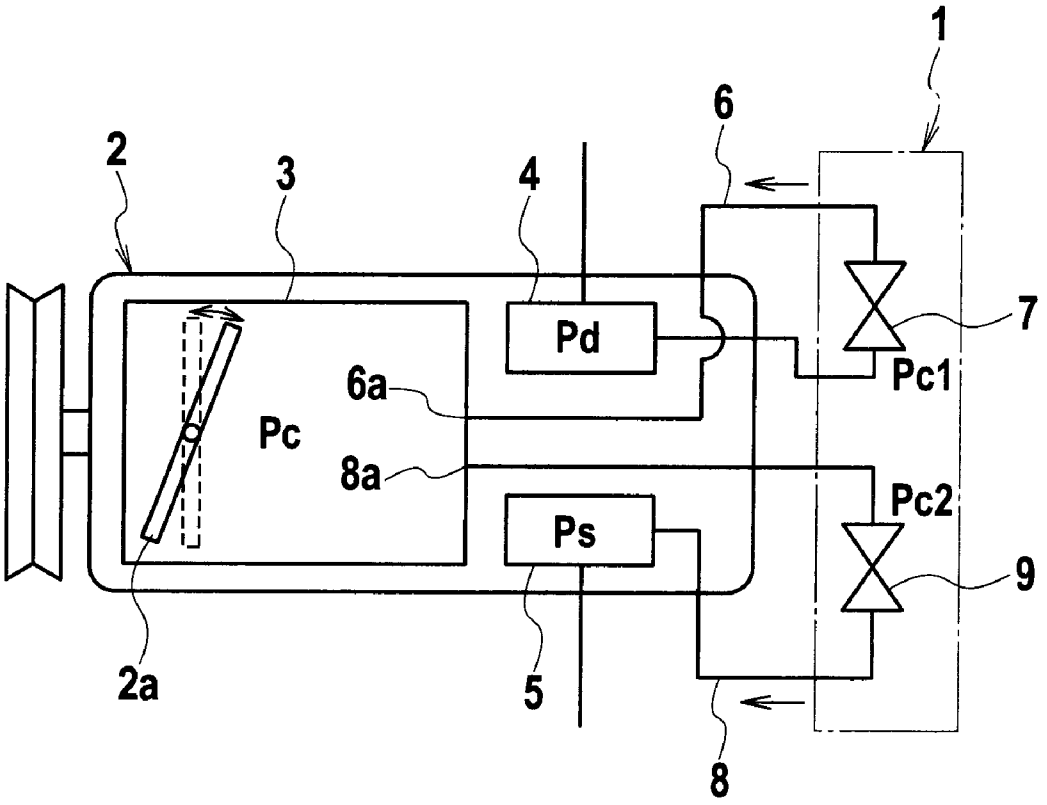


FIG. 2

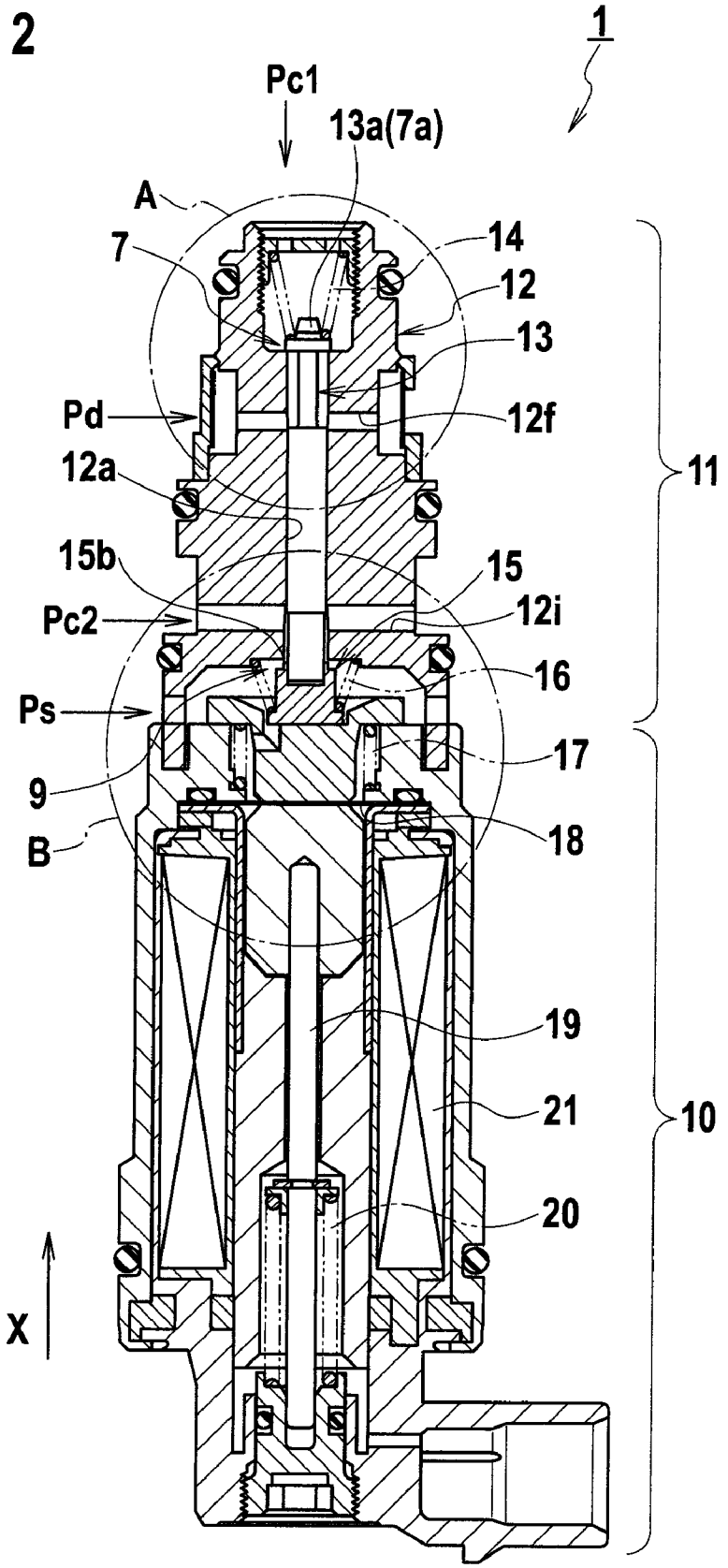

1
Pc1
13a(7a)
A
7
14
12
13
Pd
12f
12a
11
15b
15
Pc2
12i
16
Ps
17
9
B
18
19
21
10
20
X

FIG. 3

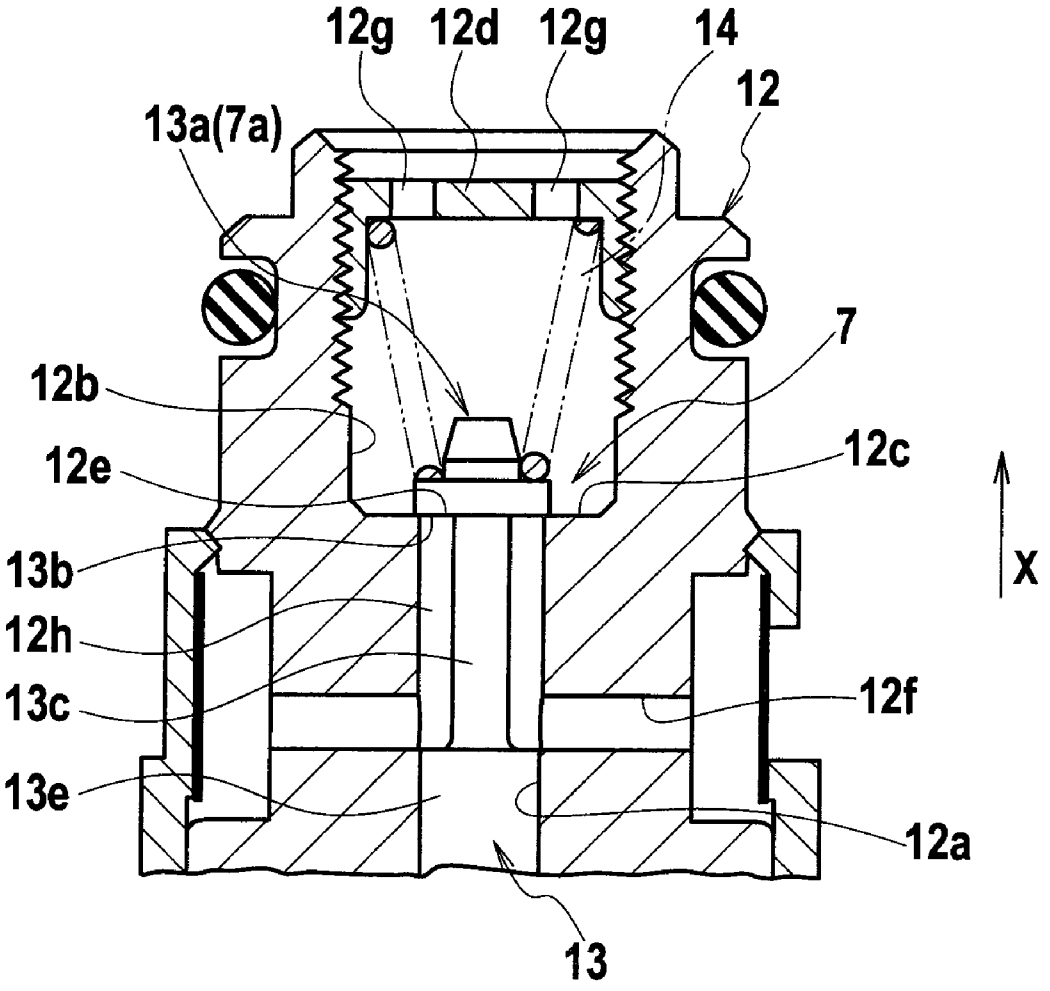


FIG. 4

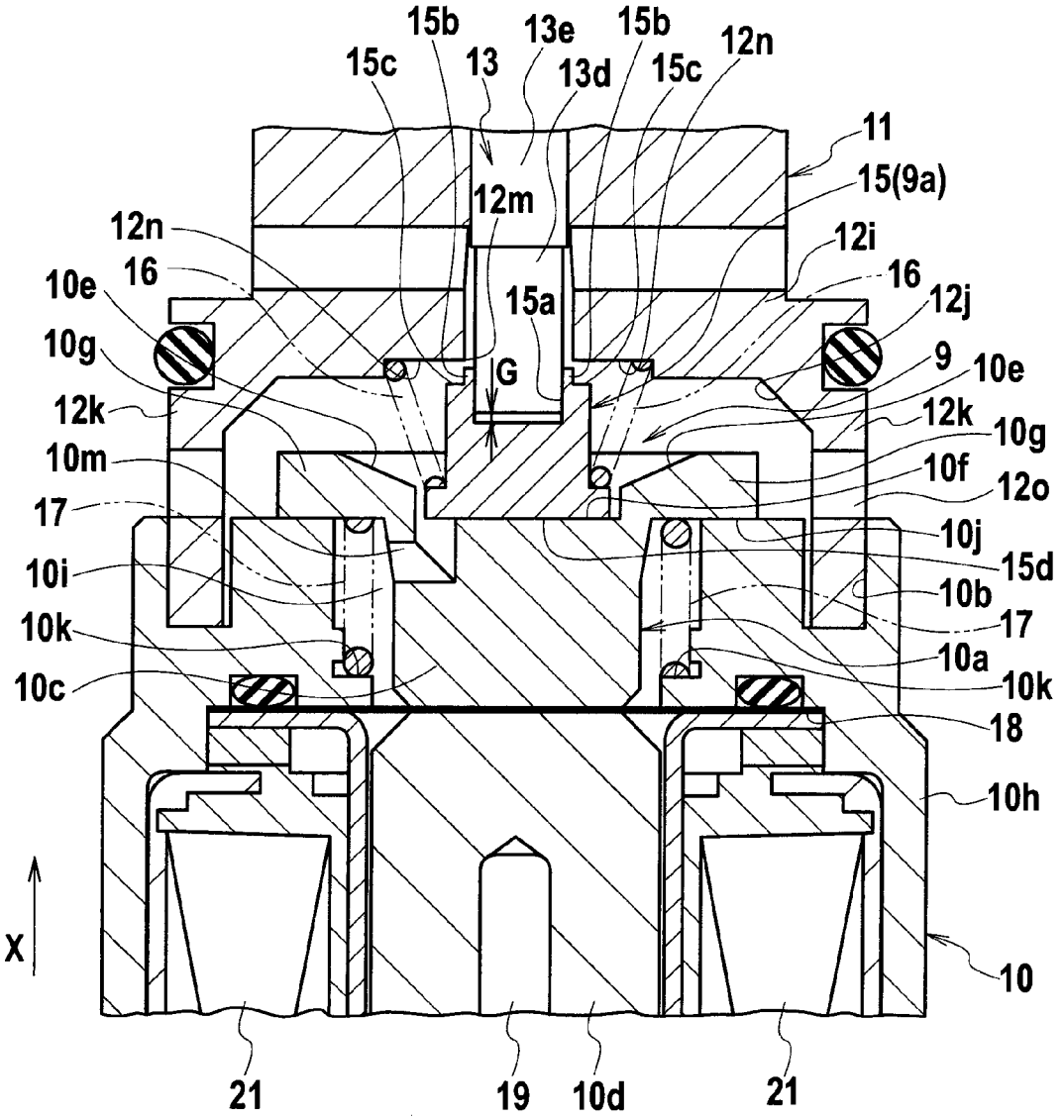

15b
13e
15b
15c
13
13d
15c
12n
11
15(9a)
12m
12n
12i
16
16
10e
15a
12j
10g
G
9
10e
12k
12k
10g
10m
10f
12o
17
10j
15d
10i
10b
17
10k
10a
10c
10k
18
10h
X
10
21
19
10d
21

FIG. 5

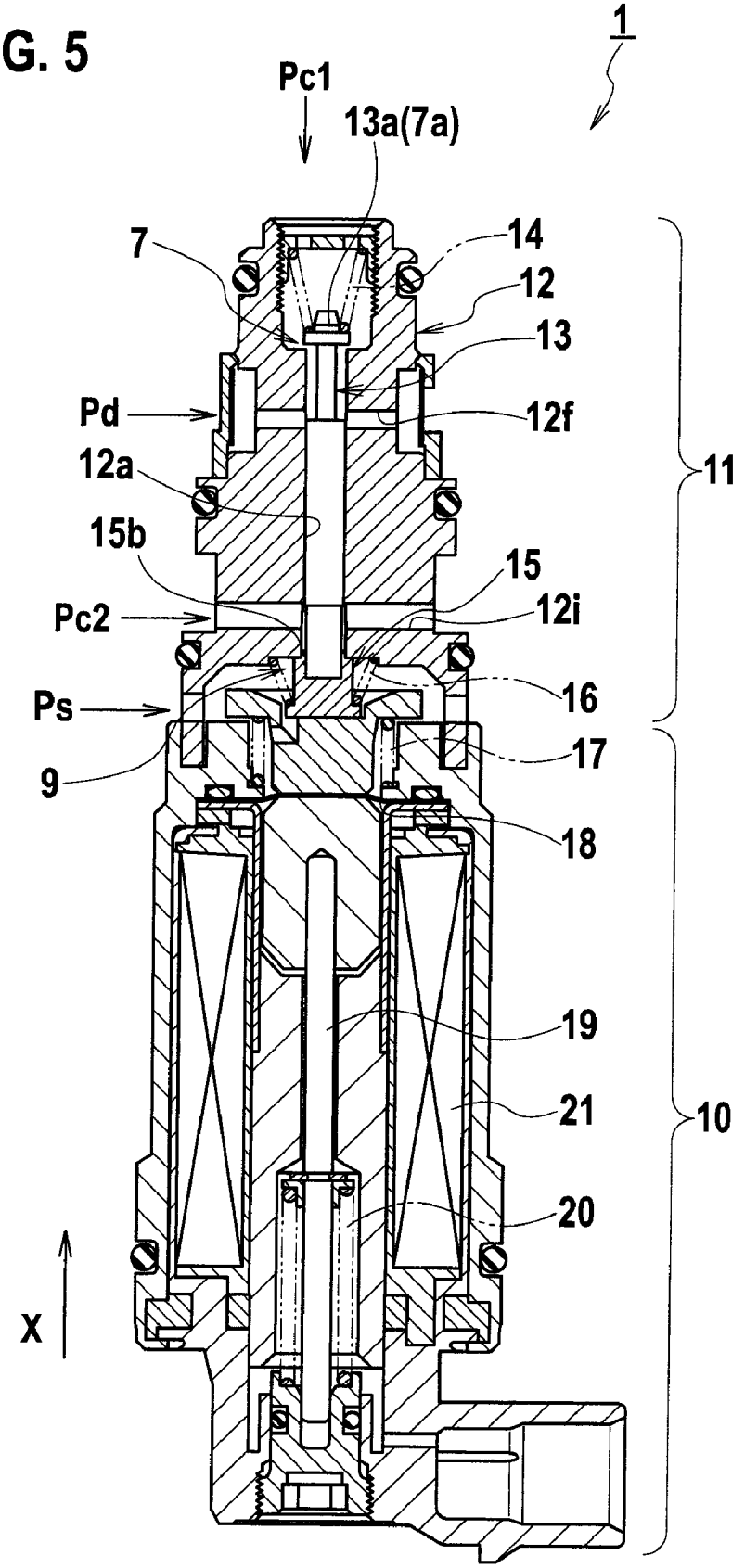
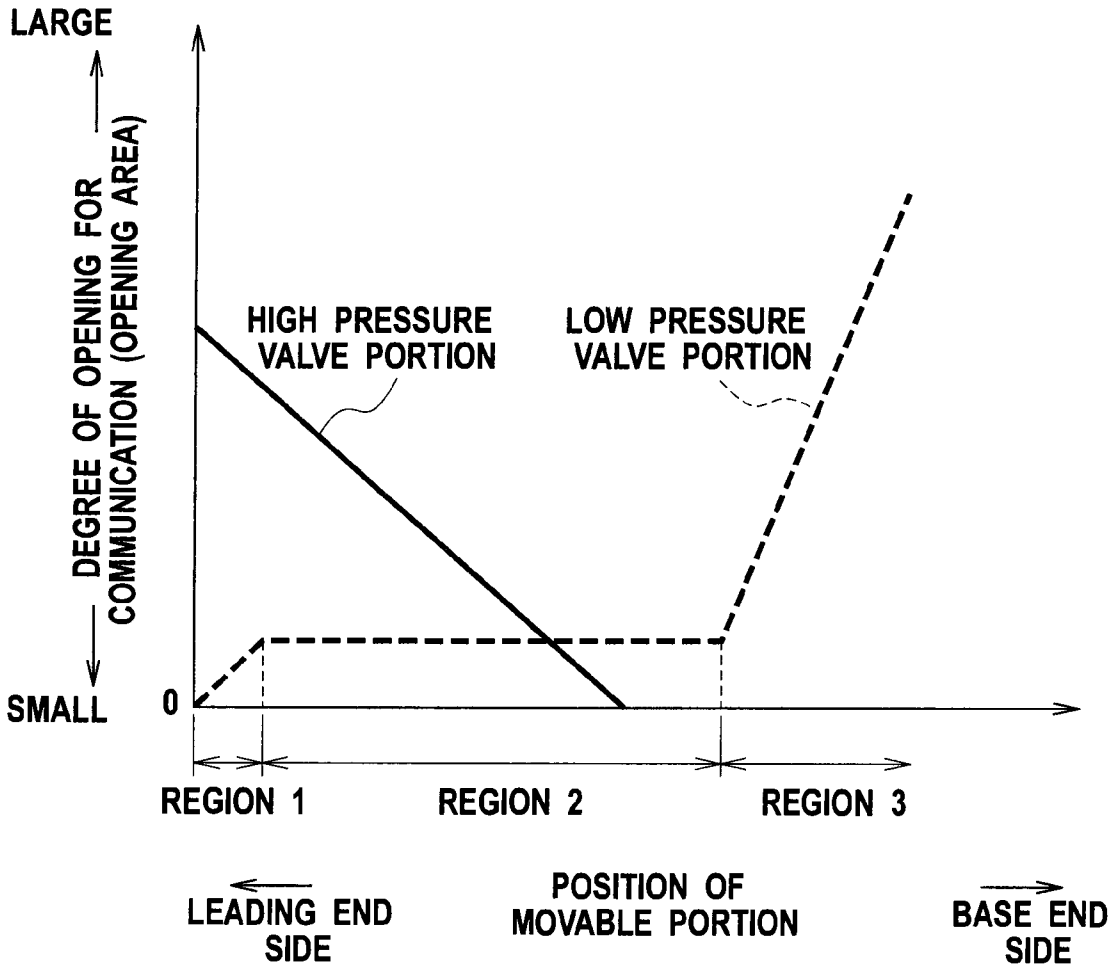

1
Pc1
13a(7a)
7
14
12
13
Pd
12f
12a
11
15b
15
Pc2
12i
16
Ps
17
9
18
19
21
10
20
X

FIG. 6


LARGE
DEGREE OF OPENING FOR COMMUNICATION (OPENING AREA)
SMALL
0
HIGH PRESSURE VALVE PORTION
LOW PRESSURE VALVE PORTION
REGION 1
REGION 2
REGION 3
LEADING END SIDE
POSITION OF MOVABLE PORTION
BASE END SIDE

CONTROL VALVE FOR VARIABLE DISPLACEMENT COMPRESSOR

TECHNICAL FIELD

[0001] The present invention relates to a control valve for a variable displacement compressor.

BACKGROUND ART

[0002] As a conventional control valve for a variable displacement compressor used for a refrigeration cycle of an automotive air conditioning system, there has been known a control valve including a high pressure valve portion provided in an introducing-side communication passage which brings a discharge flow path and a control pressure chamber of the variable displacement compressor into communication with each other, and a low pressure valve portion provided in a discharging-side communication passage which brings an intake flow path and the control pressure chamber, in which a degree of opening for communication between the high pressure valve portion and the low pressure valve portion is variably controlled, thereby changing a pressure in the control pressure chamber to change an angle of a swash plate.

[0003] According to such a configuration, a case chamber (crank chamber) is used as the control pressure chamber in many cases. In such a case, if a control pressure (pressure in the control pressure chamber) is increased, the angle of the swash plate is reduced and the discharge capacity is reduced, and if the control pressure is reduced, the angle of the swash plate is increased and the discharge capacity is increased (patent document 1, for example).

[0004] In the control valve disclosed in the patent document 1, however, in a ball valve as the high pressure valve portion, a discharge pressure is applied in a direction closing a valve body. Therefore, when control is performed to reduce the angle of the swash plate to reduce the discharge capacity, there is concern that the high pressure valve portion is closed unintentionally by the discharge pressure, the control pressure is reduced, the angle of the swash plate is increased and the discharge capacity is increased.

[0005] In addition to the high pressure valve portion having the ball valve, there is also a conventional high pressure valve portion in which a valve body of the low pressure valve portion is integrally formed on a spool valve as the high pressure valve portion. In such a case, there is a problem that since a pressure leaks from a clearance generated between a sleeve and a spool in the high pressure valve portion, the actuation of the air conditioning system delays when the cooling operation is started.

[0006] Therefore, it is an object of the present invention to obtain a control valve for a variable displacement compressor capable of preventing a high pressure valve portion from being unintentionally closed by increase of a discharge pressure, capable of preventing an angle of a swash plate from increasing, and capable of enhancing the actuating performance. Patent document 1: International Publication WO2004/065789

DISCLOSURE OF INVENTION

[0007] According to the present invention, a control valve for a variable displacement compressor comprises a high pressure valve portion provided in an introducing-side communication passage which brings a discharge flow path and a control pressure chamber of the variable displacement compressor into communication with each other, and a low pressure valve portion provided in a discharging-side communication passage which brings an intake flow path and the control pressure chamber into communication with each other, in which degree of opening for communication of the high pressure valve portion and the low pressure valve portion are variably controlled, thereby varying a pressure in the control pressure chamber to change an angle of a swash plate, wherein the control valve further comprises a position control unit which controls advancing/retracting positions of a high pressure-side valve body of the high pressure valve portion and a low pressure-side valve body of the low pressure valve portion, as a position of the high pressure-side valve body positioned by the position control unit is closer to one side, a degree of opening for communication of the high pressure valve portion is more widened, a pressure on the side of a discharge flow path acting on the high pressure-side valve body is weakened, as a position of the low pressure-side valve body positioned by the position control unit is closer to the other side, a degree of opening for communication of the low pressure valve portion is more widened, and when the high pressure-side valve body and the low pressure-side valve body are integrally positioned on the one side by the position control unit and the low pressure-side valve body is positioned on the other side by the position control unit, the high pressure-side valve body and the low pressure-side valve body are separated from each other.

[0008] According to the present invention, when the high pressure-side valve body and the low pressure-side valve body are positioned on the one side by the position control unit, the low pressure valve portion is fully closed.

[0009] According to the present invention, there is provided an urging unit which urges, of the high pressure-side valve body and the low pressure-side valve body, only the low pressure-side valve body toward the other side.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic diagram of apparatus configurations of a variable displacement compressor and a control valve according to an embodiment of the present invention.

[0011] FIG. **2** is a vertical sectional view of the control valve for the variable displacement compressor according to the embodiment of the present invention, and shows that a high pressure valve portion is closed and a low pressure valve portion is opened.

[0012] FIG. **3** is an enlarged view of a portion A in FIG. **2**.

[0013] FIG. **4** is an enlarged view of a portion B in FIG. **2**.

[0014] FIG. **5** is a vertical sectional view of the control valve for the variable displacement compressor according to the embodiment of the present invention, and shows that the high pressure valve portion is opened and the low pressure valve portion is closed.

[0015] FIG. **6** is a graph showing a correlation between a position of a movable portion of the control valve for the variable displacement compressor and opening areas of the high pressure valve portion and the low pressure valve portion according to the embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016] An embodiment of the present invention will be explained below in detail with reference to the accompanying drawings. FIG. **1** is a schematic diagram of apparatus con-

figurations of a variable displacement compressor and a control valve according to the embodiment, FIG. **2** is a vertical sectional view of the control valve, and shows that a high pressure valve portion is closed and a low pressure valve portion is opened, FIG. **3** is an enlarged view of a portion A in FIG. **2**, FIG. **4** is an enlarged view of a portion B in FIG. **2**, FIG. **5** is a vertical sectional view of the control valve, and shows that the high pressure valve portion is opened and the low pressure valve portion is closed, and FIG. **6** is a graph showing a correlation between a position of a movable portion of the control valve and opening areas of the high pressure valve portion and the low pressure valve portion.

[0017] As shown in FIG. **1**, a control valve **1** according to the present embodiment controls a control pressure Pc which changes an inclination angle of a swash plate **2***a* to change a discharge capacity of a variable displacement compressor **2**, and the control valve **1** controls a pressure (control pressure) Pc in a case chamber **3** as a control pressure chamber for example. In this case, the lower the pressure Pc in the case chamber **3** is, the greater a pressure difference applied to a piston in the variable displacement compressor **2** becomes and the discharge capacity is increased. On the contrary, the higher the pressure in the case chamber **3** is, the lower the discharge capacity becomes.

[0018] The control pressure Pc is produced as an intermediate pressure between a pressure of refrigerant (discharge pressure) Pd in a discharge flow path **4** (e.g., discharge port) and a pressure of refrigerant (intake pressure) Ps in an intake flow path **5** (e.g., intake port). For this purpose, the control valve **1** includes a high pressure valve portion **7** and a low pressure valve portion **9**. The high pressure valve portion **7** is provided in an introducing-side communication passage **6** which brings the discharge flow path **4** and the case chamber **3** into communication with each other. The high pressure valve portion **7** variably controls a degree of opening for communication of the introducing-side communication passage **6**. The low pressure valve portion **9** is provided in a discharging-side communication passage **8** which brings the intake flow path **5** and the case chamber **3** into communication with each other. The low pressure valve portion **9** variably controls a degree of opening for communication of the discharging-side communication passage **8**. By adjusting these degrees of opening for communication, the control pressure Pc is produced. In the case of such a configuration, as the degree of opening for communication of the high pressure valve portion **7** is larger, the control pressure Pc becomes closer to the discharge pressure Pd and becomes higher, and as the degree of opening for communication of the low pressure valve portion **9** is larger, the control pressure Pc becomes closer to the intake pressure Ps and becomes lower. By controlling the degree of opening for communication of the high pressure valve portion **7** and the degree of opening for communication of the low pressure valve portion **9**, it is possible to produce the control pressure Pc while suppressing the refrigerant from flowing out from the discharge flow path **4** toward the intake flow path **5** and while reducing the energy loss.

[0019] In the present embodiment, the flow path (including the introducing-side communication passage **6** and the discharging-side communication passage **8**) of refrigerant used for producing the control pressure Pc is also used as a refrigerant circulating path in the case chamber **3**, and the flow path is used for lubricating and cooling a sliding portion. For this reason, an opening **6***a* of the introducing-side communication passage **6** facing the case chamber **3** and an opening **8***a* of the discharging-side communication passage **8** facing the case chamber **3** are appropriately separated from each other, and a refrigerant path extending from the high pressure valve portion **7** to the low pressure valve portion **9** is long for some distance. Therefore, a pressure Pa in the high pressure valve portion **7** on the side of the case chamber **3** is slightly higher than a pressure Pc**2** in the low pressure valve portion **9** on the side of the case chamber **3**.

[0020] As shown in FIG. **2**, the control valve **1** includes a solenoid **10** in which a solenoid as a position control unit is incorporated, and a valve portion **11** in which the high pressure valve portion **7** and the low pressure valve portion **9** are incorporated.

[0021] In the valve portion **11**, a valve body (high pressure-side valve body **7***a*) of the high pressure valve portion **7** and a valve body (low pressure-side valve body **9***a*) of the low pressure valve portion **9** are positioned and abutted against each other in tandem in an advancing/retracting direction of a movable portion **10***a* of the solenoid, and the valve bodies are pushed against the movable portion **10***a* by coil springs **14** and **16** as an urging unit. By making the advancing/retracting position of the movable portion **10***a* variable, positions of the high pressure-side valve body **7***a* and the low pressure-side valve body **9***a* are made variable, and the degree of opening for communication of the high pressure valve portion **7** and the low pressure valve portion **9** can be controlled. In the present embodiment, the low pressure-side valve body **9***a* is positioned on the side closer to the movable portion **10***a*, and the high pressure-side valve body **7***a* is positioned on the side further from the movable portion **10***a*. In the following description, the direction of the arrow X in FIGS. **2** to **5** is called a leading end side, and the opposite direction is called a base end side for convenience sake. The movable portion **10***a*, the low pressure-side valve body **9***a* and the high pressure-side valve body **7***a* advance and retract along the X direction. The X direction extends along axial directions of a sleeve **12**, a spool **13** and the movable portion **10***a* of the solenoid.

[0022] The valve portion **11** includes a substantially cylindrical sleeve **12** formed with a through hole **12***a* in its longitudinal direction. The through hole **12***a* has a circular cross section. The spool **13** is inserted into the through hole **12***a* with an appropriate clearance, and the spool **13** can advance and retract in the through hole **12***a* along its longitudinal direction.

[0023] The high pressure valve portion **7** is formed on the leading end side of the valve portion **11**. A concrete configuration of the high pressure valve portion **7** will be explained with reference to FIGS. **2** and **3**.

[0024] A bottomed cylindrical recess **12***b* is formed on the leading end side of the through hole **12***a* of the sleeve **12**. The recess **12***b* has a diameter greater than that of the through hole **12***a*. A side of an opening **12***e* of the recess **12***b* is closed with a lid **12***d*.

[0025] An umbrella-like poppet **13***a* is formed on a leading end of the spool **13**. The poppet **13***a* projects slightly radially outward of the through hole **12***a*. The poppet **13***a* is accommodated in the recess **12***b*. In a state shown in FIGS. **2** and **3**, a bottom surface **13***b* of the poppet **13***a* and a bottom surface **12***c* of the recess **12***b* are abutted against each other. In the present embodiment, the poppet **13***a* corresponds to the high pressure-side valve body **7***a* of the high pressure valve portion

7, and the bottom surface **12***c* of the recess **12***b* corresponds to its sealing surface (sitting surface).

[0026] The coil spring **14** as an urging unit is interposed between the lid **12***d* and the poppet **13***a*. The poppet **13***a* is urged toward the base end side in the X direction, in the closing direction of the high pressure-side valve body **7***a* by the coil spring **14**.

[0027] A lateral hole port **12***f* intersecting with the through hole **12***a* is formed in the sleeve **12** at a location separating away from the opening **12***e* on the leading end side of the through hole **12***a* toward the base end side in the X direction by a predetermined distance. A diameter-reduced portion **13***c* which is narrowed is formed in the spool **13** from the bottom surface **13***b* of the poppet **13***a* to a location opposed to the lateral hole port **12***f*. The diameter-reduced portion **13***c* has a substantially constant circular cross section.

[0028] A side of the introducing-side communication passage **6** on the side of the case chamber **3** which is not shown in FIGS. **2** or **3** is in communication with the recess **12***b* through a through hole **12***g* formed in the lid **12***d*, and a side of the introducing-side communication passage **6** on the side of the discharge flow path **4** is in communication with the lateral hole port **12***f*. A pressure in the recess **12***b*, i.e., a back pressure of the poppet **13***a* becomes a control pressure (Pa), and a pressure in a gap **12***h* corresponding to the lateral hole port **12***f* and the diameter-reduced portion **13***c* of the spool **13** becomes the discharge pressure Pd.

[0029] The discharge pressure Pd is applied to an end surface of the diameter-reduced portion **13***c* of the spool **13** on the side of the leading end in the X direction toward the leading end side of the X direction, and the discharge pressure Pd is applied to an end surface of the diameter-reduced portion **13***c* of the spool **13** on the side of the base end in the X direction toward the leading end side in the X direction. Therefore, the discharge pressure Pd applied to the spool **13** is weakened (offset) in the axial direction of the spool **13**.

[0030] In the configuration described above, if the spool **13** moves toward the leading end side in the X direction and the poppet **13***a* as the high pressure-side valve body **7***a* is separated away from the bottom surface **12***c* as the sitting surface, the high pressure valve portion **7** is opened and the introducing-side communication passage **6** is brought into communication. The degree of opening for communication of the high pressure valve portion **7** becomes larger in accordance with a distance of the poppet **13***a* separated away from the bottom surface **12***c*. A state where the spool **13** is located at the nearest position of the base end side in the X direction and the poppet **13***a* sits on the bottom surface **12***c* corresponds to a state where the high pressure valve portion **7** closes. In this state, the introducing-side communication passage **6** is shut. According to this configuration, the poppet **13***a* is pushed against the bottom surface **12***c* such that the poppet **13***a* conforms to the bottom surface **12***c*, thereby enhancing the sealing performance of the high pressure valve portion **7**. The position of the poppet **13***a* in the X direction, i.e., the degree of opening for communication of the high pressure valve portion **7** is controlled by a solenoid as a later-described position control unit.

[0031] The low pressure valve portion **9** is formed on the valve portion **11** on the side of the base end. A concrete configuration of the low pressure valve portion **9** will be explained with reference to FIGS. **2**, **4**, and **5**.

[0032] Another lateral hole port **12***i* intersecting with the through hole **12***a* is formed in the sleeve **12** at a location separating away from the lateral hole port **12***f* by a predetermined distance toward the base end side in the X direction. A diameter-reduced portion **13***d* which is narrowed from a location opposed to the lateral hole port **12***i* to an end on the base end side is formed on the spool **13**. The diameter-reduced portion **13***d* has a substantially constant circular cross section.

[0033] A clearance between the through hole **12***a* and a section of the spool **13** (general portion **13***e*) existing between the lateral hole port **12***f* and the lateral hole port **12***i* is narrowed so that leakage of refrigerant between the lateral hole ports **12***f* and **12***i* is reduced.

[0034] A bottomed cylindrical recess **12***j* is formed in the sleeve **12** on the base end side from the through hole **12***a*. The recess **12***j* has a diameter greater than that of the through hole **12***a*. A leading end of a sidewall **12***k* of the recess **12***j* is press-fitted into a recess groove **10***b* formed in the leading end of the solenoid **10**. With this configuration, the valve portion **11** and the solenoid **10** are coupled to each other.

[0035] A poppet **15** as the low pressure-side valve body **9***a* is positioned in the recess **12***j*. A substantially cylindrical recess **15***a* is formed in the poppet **15**. The diameter-reduced portion **13***d* of the spool **13** is loosely inserted into the recess **15***a*.

[0036] An annular projection **15***b* is provided on the poppet **15** on the leading end side in the X direction. As shown in FIG. **5**, in a state where the poppet **15** is located at the furthest position of the leading end side in the X direction, the projection **15***b* is inserted into the through hole **12***a* from its opening **12***m* on the base end side of the through hole **12***a*, and a top surface **15***c* around the projection **15***b* and a bottom surface **12***n* of the recess **12***j* abut against each other. As described above, in the present embodiment, the poppet **15** corresponds to the low pressure-side valve body **9***a* of the low pressure valve portion **9**, and the bottom surface **12***n* of the recess **12***j* corresponds to its sealing surface (sitting surface).

[0037] A coil spring **16** as an urging unit is interposed between the bottom surface **12***n* and the poppet **15**. The poppet **15** is urged toward the base end side in the X direction, in the opening direction of the low pressure-side valve body **9***a* by the coil spring **16**.

[0038] A side of the discharging-side communication passage **8** (not shown in FIGS. **2**, **4**, and **5**) closer to the case chamber **3** is in communication with the lateral hole port **12***i*, and a side of the discharging-side communication passage **8** closer to the intake flow path **5** is in communication with the recess **12***j* through a through hole **12***o* formed in the sidewall **12***k*. With this configuration, a pressure in the recess **12***j*, i.e., a back pressure of the poppet **15** is the intake pressure Ps, and a pressure in the lateral hole port **12***i* is the control pressure (Pc**2**).

[0039] That is, in the present embodiment, if the spool **13** moves toward the base end side in the X direction and the poppet **15** as the low pressure-side valve body **9***a* separates from the bottom surface **12***n* as the sitting surface, the low pressure valve portion **9** opens and the discharging-side communication passage **8** is brought into communication. The degree of opening for communication of the low pressure valve portion **9** becomes larger in accordance with a distance of the poppet **15** separated away from the bottom surface **12***n*. A state where the spool **13** is located at the furthest position of the leading end side in the X direction and the poppet **15** sits on the bottom surface **12***n* corresponds to a state where the low pressure valve portion **9** is closed. In this state, the discharging-side communication passage **8** is blocked.

[0040] According to this configuration, the poppet **15** is pushed against the bottom surface **12***n* such that the poppet **15** conforms to the bottom surface **12***n*, thereby enhancing the sealing performance of the low pressure valve portion **9**. The position of the poppet **15** in the X direction, i.e., the degree of opening for communication of the low pressure valve portion **9** is controlled by a solenoid as a later-described position control unit.

[0041] The movable portion **10***a* of the solenoid **10** is positioned on the base end side of the poppet **15** as the low pressure-side valve body **9***a*.

[0042] In the present embodiment, the movable portion **10***a* has such a shape that a first member **10***c* located on the leading end side in the X direction and a second member **10***d* located on the base end side are arranged in the X direction and are integrally coupled to each other. A recess **10***e* is formed in the first member **10***c*. A leading end side of the recess **10***e* is widened in a conical shape and a base end of the recess **10***e* is of a cylindrical shape. The poppet **15** is loosely inserted into the recess **10***e*. At that time, a bottom surface **15***d* of the poppet **15** abuts against a bottom surface **10***f* of the recess **10***e*, and the poppet **15** is pushed against the first member **10***c* by the coil spring **16**. An axial deviation between the poppet **15** and the movable portion **10***a* can be absorbed by a clearance between an inner wall of the recess **10***e* and an outer wall of the poppet **15**.

[0043] A flange **10***g* is formed on a leading end of the first member **10***c*. The flange **10***g* is latched together with an opening edge of a recess **10***i* formed in leading end side of the casing **10***h* of the solenoid **10**, thereby limiting the movement of the movable portion **10***a* toward the base end side.

[0044] A coil spring **17** as an urging unit is interposed between a back surface **10***j* of the flange **10***g* and a step **10***k* formed on a sidewall of the recess **10***i*. The movable portion **10***a* is urged toward the leading end side in the X direction by the coil spring **17**.

[0045] The recess **10***i* is isolated by an annular plate-like diaphragm **18**. A peripheral edge of the diaphragm **18** is attached to the casing **10***h* in a sealed manner, and a central portion of the diaphragm **18** is nipped between the first member **10***c* and the second member **10***d* in a sealed manner.

[0046] The recess **10***i* is in communication with the recess **12***j* through a passage **10***m* which penetrates front and back surfaces of the flange **10***g*. Therefore, a pressure in the recess **10***i*, i.e., a pressure acting on a surface (front surface) of the diaphragm **18** on the side of the leading end is the intake pressure Ps. A pressure acting on a surface (back surface) of the diaphragm **18** on the side of the base end is the atmospheric pressure. Therefore, if the intake pressure Ps exceeds a predetermined value, the movable portion **10***a* is moved toward the base end side by a pressure difference acting on the diaphragm **18**.

[0047] A shaft **19** is coupled to the movable portion **10***a*. The shaft **19** is urged toward the leading end side by a coil spring **20** as an urging unit positioned on the base end side.

[0048] In the above configuration, if a coil **21** is energized, a suction force acting toward the base end side is applied to the movable portion **10***a* (second member **10***d*). By adjusting the suction force by controlling current flowing to the coil **21**, positions, in the X direction, of the movable portion **10***a*, the poppet **15** as the low pressure-side valve body **9***a* which abuts against the movable portion **10***a*, and the poppet **13***a* as the high pressure-side valve body **7***a* provided on the spool **13** which abuts against the poppet **15** are determined by balance between the suction force and the urging forces of the coil springs **14**, **16**, **17**, and **20** as the urging unit.

[0049] If the movable portion **10***a* is moved toward the base end side by controlling the current supplied to the coil **21** or by increasing the intake pressure Ps acting on the diaphragm **18**, the poppet **15** as the low pressure-side valve body **9***a* is also moved toward the base end side in association with the movable portion **10***a* by the spring force of the coil spring **16** as the urging unit, and the poppet **13***a* as the high pressure-side valve body **7***a* provided on the spool **13** is also moved toward the base end side in association with the movable portion **10***a* by the spring force of the coil spring **14** as the urging unit.

[0050] According to the present embodiment, however, since poppet **15** and the spool **13** provided with the poppet **13***a* are not coupled to each other and they can separate from each other, after the poppet **13***a* as the high pressure-side valve body **7***a* sits on the bottom surface **12***c* as the sitting surface, the poppet **15** separates from the spool **13** as shown in FIG. **2**, and the degree of opening for communication of only the low pressure valve portion **9** becomes larger.

[0051] FIG. **6** shows the degree of opening for communications of the high pressure valve portion **7** and the low pressure valve portion **9** with respect to the position, in the X direction, of the movable portion **10***a* in the control valve **1** having the configuration described above. In FIG. **6**, the lateral axis shows a position of the movable portion **10***a* in the X direction, the right side is the base end side, and the left side is the leading side. The vertical axis shows the degree of opening for communication (an area of opening).

[0052] The degree of opening for communication of the high pressure valve portion **7** is linearly varied depending upon the position of the movable portion **10***a*, i.e., the position of the poppet **13***a*. That is, in a state where the movable portion **10***a* is located at the furthest position of the leading end side (FIG. **5**), the degree of opening for communication of the high pressure valve portion **7** becomes the maximum, the degree of opening for communication of the high pressure valve portion **7** is linearly reduced as the position of the movable portion **10***a* is varied toward the base end side. When the poppet **13***a* as the high pressure-side valve body **7***a* abuts against the bottom surface **12***c* as the sitting surface, the high pressure valve portion **7** closes and its degree of opening for communication becomes 0. If the high pressure valve portion **7** closes, the supply of refrigerant into the case chamber **3** through the introducing-side communication passage **6** is stopped, but refrigerant can be supplied into the case chamber **3** due to leakage from the clearance between the piston and the cylinder.

[0053] The degree of opening for communication of the low pressure valve portion **9** is also varied in accordance with the position of the movable portion **10***a*, but the manner of variation of the degree of opening for communication differs depending upon the position of the movable portion **10***a*. That is, when the movable portion **10***a* is located at the furthest position of the leading end side direction, the poppet **15** as the low pressure-side valve body **9***a* abuts against the bottom surface **12***n* as the sitting surface and the low pressure valve portion **9** is closed.

[0054] If the position of the movable portion **10***a* is varied to the base end side, the poppet **15** separates from the bottom surface **12***n*. While the poppet **15** is not separated from the bottom surface **12***n* so much, the degree of opening for communication is varied linearly (region **1**). Thereafter, even if

the distance between the poppet **15** and the bottom surface **12***n* is increased, if the projection **15***b* is still inserted into the through hole **12***a*, the clearance between the projection **15***b* and the through hole **12***a* occupies the most of the degree of opening for communication of the low pressure valve portion **9**, and this degree of opening for communication is equivalent to a fixed orifice. Therefore, in this section, the degree of opening for communication is varied substantially constantly (region **2**). Thereafter, if the projection **15***b* is pulled out from the through hole **12***a*, the degree of opening for communication of the low pressure valve portion **9** is linearly increased in accordance with the distance between the poppet **15** and the bottom surface **12***n* (region **3**). In this region **3**, the poppet **15**, i.e., the low pressure-side valve body **9***a* separates from the poppet **13***a*, i.e., the spool **13** having the high pressure-side valve body **7***a* (gap G). Therefore, the high pressure valve portion **7** is closed and the movement of the high pressure-side valve body **7***a* toward the base end side is limited, but irrespective of this, the degree of opening for communication of the low pressure valve portion **9** can swiftly be larger.

[0055] According to the present embodiment, as described above, the discharge pressure Pd acting to the poppet **13***a* as the high pressure-side valve body **7***a* acts on both the base end side and the leading end side of the spool **13** in the X direction and the discharge pressure Pd is weakened. Therefore, unlike the conventional technique, it is possible to avoid a case where when the high pressure valve portion is opened, the high pressure valve portion is closed by the discharge flow path side pressure Pd acting on the high pressure-side valve body and a pressure in the case chamber is reduced. Thus, it is possible to avoid a case where in a state in which the angle of the swash plate **2***a* of the variable displacement compressor **2** is small, the degree of opening for communication of the high pressure valve portion **7** is reduced or closed, a pressure in the case chamber **3** is reduced and the angle of the swash plate **2***a* is increased.

[0056] That is, according to the present embodiment, it is possible to keep the angle of the swash plate **2***a* small and to reliably obtain a state where there is almost no discharge capacity. Therefore, this is suitably applied to a variable displacement compressor for a so-called clutch-less system. In this case, as compared with a system which stops rotation of a compressor using a clutch, there is a merit that the number of parts is reduced, the apparatus configuration can be simplified and its weight can be reduced.

[0057] According to the present embodiment, when the poppet **15** as the low pressure-side valve body **9***a* is positioned on the side of the base end by the solenoid **10** as the position control unit, the poppet **13***a* as the high pressure-side valve body **7***a* and the poppet **15** as the low pressure-side valve body **9***a* are separated from each other. Therefore, the degree of opening for communication of the low pressure valve portion **9** can be widened and the poppet **15** is not subjected to any constraints by the poppet **13***a*. Therefore, when the variable displacement compressor **2** is started, the degree of opening for communication of the low pressure valve portion **9** can be larger more swiftly, the control pressure Pc in the case chamber **3** can be reduced, the angle of the swash plate **2***a* can be increased, and a necessary discharge capacity can be secured more swiftly.

[0058] Further, since the high pressure-side valve body **7***a* and the low pressure-side valve body **9***a* can be separated from each other, even if a discharge pressure Pd acts on the high pressure-side valve body **7***a* toward the leading end side in the X direction, the movement of the low pressure-side valve body **9***a* toward the base end side in the X direction is not hindered.

[0059] According to the present embodiment, the low pressure valve portion **9** is fully closed when the poppet **13***a* as the high pressure-side valve body **7***a* and the poppet **15** as the low pressure-side valve body **9***a* are positioned on the side of the leading end by the solenoid **10** as the position control unit. Therefore, it becomes easy to keep the control pressure Pc in the case chamber **3** high, the leaking flow in the low pressure valve portion **9** can be reduced and the energy loss can be reduced correspondingly.

[0060] Since the low pressure valve portion **9** is configured such that it closes, the degree of opening for communication when the low pressure valve portion **9** is closed is naturally small as compared with a case where the low pressure valve portion **9** is configured such that it does not close. However, according to the present embodiment, since the high pressure-side valve body **7***a* and the low pressure-side valve body **9***a* can be separated from each other, the degree of opening for communication of the low pressure valve portion **9** can be larger more swiftly as compared with a case where the high pressure-side valve body **7***a* and the low pressure-side valve body **9***a* are integrally formed as one piece, and a state where the low pressure valve portion **9** is closed, i.e., a state where the control pressure Pc in the case chamber **3** is high can be switched, more swiftly, to a state where the low pressure valve portion **9** is opened, i.e., a state where the control pressure Pc in the case chamber **3** is low, and the control response can be enhanced.

[0061] Furthermore, according to the present embodiment, the poppet **13***a* and the poppet **15** can be separated more swiftly by the coil spring **17** which does not urge the poppet **13***a* and which urges only the poppet **15** toward the base end side. Therefore, the degree of opening for communication of the low pressure valve portion **9** can be larger more swiftly, and the control response can be enhanced.

[0062] While a preferred embodiment of the present invention has been described above, the invention is not limited to the embodiment and can be variously modified. For example, the poppet valve can be changed to a ball valve or a needle valve. The direction of the suction force cause by the solenoid, the configuration to generate the suction force, the configuration of the valve portion, the configuration of the urging unit and the like are not limited to those of the embodiment.

INDUSTRIAL APPLICABILITY

[0063] The present invention can be utilized as a control valve for a variable displacement compressor.

1. A control valve for a variable displacement compressor comprising a high pressure valve portion provided in an introducing-side communication passage which brings a discharge flow path and a control pressure chamber of the variable displacement compressor into communication with each other, and a low pressure valve portion provided in a discharging-side communication passage which brings an intake flow path and the control pressure chamber into communication with each other, in which degree of opening for communication of the high pressure valve portion and the low pressure valve portion are variably controlled, thereby varying a pressure in the control pressure chamber to change an angle of a swash plate, wherein

the control valve further comprises a position control unit which controls advancing/retracting positions of a high

pressure-side valve body of the high pressure valve portion and a low pressure-side valve body of the low pressure valve portion,

as a position of the high pressure-side valve body positioned by the position control unit is closer to one side, a degree of opening for communication of the high pressure valve portion is more widened, a pressure on the side of a discharge flow path acting on the high pressure-side valve body is weakened,

as a position of the low pressure-side valve body positioned by the position control unit is closer to the other side, a degree of opening for communication of the low pressure valve portion is more widened, and

when the high pressure-side valve body and the low pressure-side valve body are integrally positioned on the one side by the position control unit and the low pressure-side valve body is positioned on the other side by the position control unit, the high pressure-side valve body and the low pressure-side valve body are separated from each other.

2. The control valve for a variable displacement compressor according to claim **1**, wherein when the high pressure-side valve body and the low pressure-side valve body are positioned on the one side by the position control unit, the low pressure valve portion is fully closed.

3. The control valve for a variable displacement compressor according to claim **1**, further comprising an urging unit which urges, of the high pressure-side valve body and the low pressure-side valve body, only the low pressure-side valve body toward the other side.

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