(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 236 068 A1

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
25.10.2017 Bulletin 2017/43

(21) Application number: **15870024.5**

(22) Date of filing: **16.12.2015**

(51) Int Cl.:
F04B 27/18 *(2006.01)*

(86) International application number:
PCT/JP2015/085259

(87) International publication number:
WO 2016/098822 (23.06.2016 Gazette 2016/25)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **18.12.2014 JP 2014256348**

(71) Applicant: **Valeo Japan Co., Ltd.**
Saitama 360-0193 (JP)

(72) Inventors:
- **AMEMORI, Masanori**
Kumagaya-shi
Saitama 360-0193 (JP)
- **OSAWA, Jin**
Kumagaya-shi
Saitama 360-0193 (JP)

(74) Representative: **Tran, Chi-Hai**
Valeo Systèmes Thermiques
8, rue Louis Lormand
CS 80517 La Verrière
78322 Le Mesnil Saint Denis Cedex (FR)

(54) **VARIABLE CAPACITY COMPRESSOR**

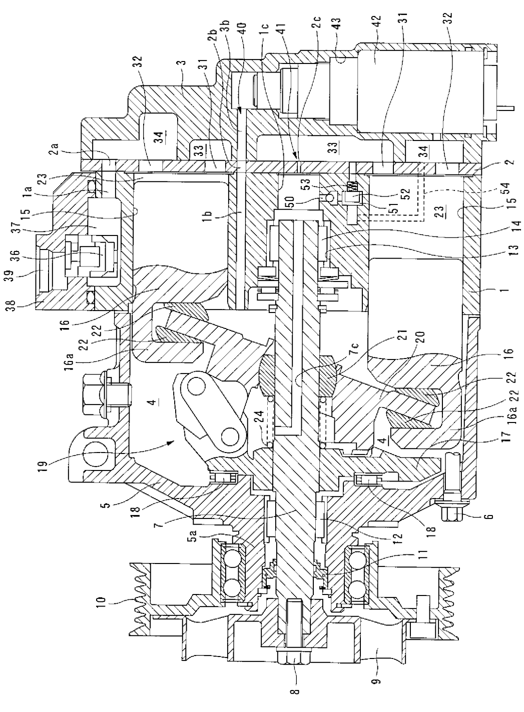
(57) [Object]

To provide a variable capacity compressor capable of improving the startup performance of the compressor, reducing the amount of refrigerant circulating internally during an intermediate stroke, and eliminating the risk of becoming out of control due to contaminants in the refrigerant or the like.

[Solution]

The variable capacity compressor includes an open passage 50 communicating a control pressure chamber 4 with a suction chamber 33 and a valve accommodating chamber 51 formed in the open passage and the open passage 50 includes an upstream side open passage 50a communicating the control pressure chamber 4 with the valve accommodating chamber 51 and a downstream side open passage 50b communicating the valve accommodating chamber 51 with the suction chamber 33. In addition, the variable capacity compressor is provided with a valve element 52 accommodated in the valve accommodating chamber 51 so as to open or close the downstream side open passage 50b, urging means (spring 53) that urges the valve element 52 so as to open the downstream side open passage 50b, a discharge pressure introduction passage 54 communicating the valve accommodating chamber 51 with the discharge chamber, and a check valve 55, provided in the upstream side open passage 50a, that allows only a flow of the fluid from the control pressure chamber 4 to the valve accommodating chamber 51.

[FIG.2]



EP 3 236 068 A1

Description

Technical Field

[0001] The present invention relates to a variable capacity compressor that changes a discharge capacity by adjusting the pressure of a control pressure chamber and, more particularly, to a variable capacity compressor that adjusts the pressure of the control pressure chamber via a supply passage communicating a discharge chamber with the control pressure chamber and a bleeding passage communicating the control pressure chamber with a suction chamber.

Background Art

[0002] A variable capacity compressor adopts a mechanism in which the stroke amount of a piston is adjusted by changing the tilt angle of a swash plate by adjusting the pressure of a control pressure chamber and the discharge capacity is thereby changed. In such a compressor, there is a known structure in which the bleeding passage communicates the control pressure chamber with the suction chamber, a control valve is provided in the supply passage communicating the discharge chamber with the control pressure chamber, and the pressure of the control pressure chamber is controlled by adjusting the amount of refrigerant flowing into the control pressure chamber by adjusting the opening of the supply passage using this control valve.

[0003] In the above pressure adjustment of the control pressure chamber, the refrigerant flowing into the control pressure chamber via the supply passage from the discharge chamber does not flow out of the compressor, but is turned back to the suction chamber. The refrigerant circulating through the compressor without circulating through the refrigeration cycle does no contribute to the refrigeration capability of the refrigeration cycle at all, so the refrigerant is preferably as little as possible to improve the performance in the intermediate stroke state.

[0004] If the compressor stops for a long time without operating, the pressures in the refrigeration cycle are balanced and refrigerant in the refrigeration cycle is liquefied in the portion of the refrigeration cycle in which the temperature is lowest. Of the components constituting the refrigeration cycle, the compressor has the largest thermal capacity and does not easily heat up following changes in the outdoor temperature, so an event of liquefaction of the refrigerant in the refrigeration cycle occurs in the compressor. When the refrigerant is liquefied in the compressor, the liquid refrigerant is also stored in the crank chamber, which is the control pressure chamber.

[0005] When the compressor is started up in the state in which the pressures are balanced, the operation of the compressor reduces the pressure in the suction chamber and the refrigerant in the crank chamber is thereby exhausted to the suction chamber via the bleeding passage. However, if liquid refrigerant is stored in the crank chamber, the inside of the crank chamber is put in the saturated state in which the gaseous phase refrigerant and the liquid phase refrigerant are present together. Accordingly, even if the refrigerant in the crank chamber is exhausted to the suction chamber via the bleeding passage, the pressure in the crank chamber is kept at the saturated pressure. Accordingly, until all liquid refrigerant is vaporized and exhausted from air bleeding passage, the pressure in the crank chamber (control pressure chamber) is not reduced, thereby causing inconvenience of disabling discharge capacity control (discharge capacity is not increased).

[0006] To solve the above problem, there is proposed a structure in which a differential pressure adjusting valve is provided to ensure the startup of the compressor by communicating the control pressure chamber with the suction chamber when the pressure difference between the discharge chamber and the suction chamber becomes equal to or less than a predetermined value (see PTL 1).

[0007] This differential pressure adjusting valve is illustrated in, for example, Fig. 6 and includes an accommodation space 102 in which a spool 101 is accommodated slidably, a high pressure port 104, formed so as to face one end side of the spool 101, that communicates with a discharge chamber 103, a low pressure port 106, formed so as to face the other end side of the spool 101, that communicates with a suction chamber 105, a control pressure port 108 that is communicable with the low pressure port 106, communicates with a control pressure chamber 107, and has an opening adjusted by the displacement of the spool 101, and a spring 109 urging the spool 101 toward the high pressure port 104.

[0008] In such a structure, when the difference between pressure Pb of the discharge chamber 103 and pressure Ps of the suction chamber 105 becomes smaller than the urging force of the spring 109, the spool 101 is displaced toward the high pressure port 104 and the control pressure port 108 communicates with the lowpressureport 106 as illustrated in Fig. 6 (a). In contrast, when the difference between pressure Pb of the discharge chamber 103 and pressure Ps of the suction chamber 105 becomes larger than the urging force of the spring 109, the spool 101 is displaced toward the low pressure port 106 against the urging force of the spring 109, closes the control pressure port 108, and blocks communication between the control pressure port 108 and the low pressure port 106 as illustrated in Fig. 6(b).

[0009] Accordingly, at the startup time when the difference between the pressure of the discharge chamber 103 and the pressure of the suction chamber 105 is small, since the control pressure port 108 communicates with the low pressure port 106 and the refrigerant in the control pressure chamber 107 is exhausted to the suction chamber 105 through two channels (the channel passing through a conventional air bleeding passage 110 and the channel through which the control pressure port 108 communicates with the low pressure port 106), the pressure of the control pressure chamber 107 can be reduced early (the time until the liquid refrigerant stored in the control pressure chamber is fully vaporized and exhausted to the suction chamber is reduced), it is possible to avoid inconvenience of extension of the time until the discharge capacity control is enabled.

[0010] After the liquid refrigerant stored in the control pressure chamber is fully vaporized and exhausted to the suction chamber, when the difference between the pressure of the discharge chamber 103 and the pressure of the suction chamber 105 is gradually increased and becomes equal to or more than a predetermined pressure difference, communication between the control pressure port 108 and the low pressure port 106 is blocked and the refrigerant in the control pressure chamber 107 is exhausted to the suction chamber 105 only through the conventional air bleeding passage 110.

[0011] An example of the structure illustrated in Fig. 7 is also proposed for the differential pressure adjusting valve. This differential pressure adjusting valve includes a spool 202 accommodated slidably in a spool accommodating unit 201 formed in the cylinder block, a ball valve 204, accommodated in a ball valve accommodating unit 203 formed next to the spool accommodating unit 201, that makes contact with the spool 202, a high pressure port 206, connected toward the end of the spool accommodating unit 201, that communicates with a discharge chamber 205, a control pressure port 208, opened in the ball valve accommodating unit 203, that communicates with a control pressure chamber 207, and a low pressure port 211 that is formed in a valve plate 209 covering the ball valve accommodating unit 203, communicates the ball valve accommodating unit 203 with a suction chamber 210, and is opened or closed by the ball valve 204. A spring 212 is inserted into the ball valve accommodating unit 203 via the low pressure port 211 from the low pressure chamber so that the ball valve 204 makes constant contact with the spool 202.

[0012] In such a structure, when the difference between the pressure of the discharge chamber 205 and the pressure of the control pressure chamber 207 becomes smaller than the urging force of the spring 212, the spool 202 is displaced toward the high pressure port 206 by the spring force of the spring 212 as illustrated in Fig. 7(a) and the control pressure port 208 communicates with the low pressure port 211.

[0013] In contrast, when the difference between the pressure of the discharge chamber 205 and the pressure of the control pressure chamber 207 is larger than the urging force of the spring 212, as illustrated in Fig. 7(b), the spool 202 urges the ball valve 204 against the urging force of the spring 212 and displaces the ball valve 204 toward the low pressure port, the ball valve 204 closes the low pressure port 211, and communication between the control pressure port 208 and the low pressure port 211 is thereby blocked.

[0014] Accordingly, at the startup time when the difference between the pressure of the discharge chamber 205 and the pressure of the control pressure chamber 207 is small, since the control pressure port 208 communicates with the low pressure port 211 and the refrigerant in the control pressure chamber 207 is exhausted to the suction chamber 210 through two channels (the channel passing through a conventional air bleeding passage 213 and the channel through which the control pressure port 208 communicates with the low pressure port 211), the pressure of the control pressure chamber 207 can be reduced early (the time until the liquid refrigerant stored in the control pressure chamber is fully vaporized and exhausted to the suction chamber is reduced), it is possible to avoid inconvenience of extension of the time until the discharge capacity control is enabled.

[0015] After the liquid refrigerant stored in the control pressure chamber is fully vaporized and released to the suction chamber, when the difference between the pressure of the discharge chamber 205 and the pressure of the suction chamber 210 is gradually increased and becomes equal to or more than a predetermined pressure difference, communication between the control pressure port 208 and the low pressure port 211 is blocked and the refrigerant in the control pressure chamber 207 is exhausted to the suction chamber 210 only through the conventional air bleeding passage 213.

Citation List

Patent Literature

[0016] PTL 1: Japanese Patent No. 4501112

Summary of Invention

Technical Problem

[0017] However, in the conventional structure described above, since the valve element accommodated in the accommodation space is configured by a spool that displaces slidably on the inner wall of the accommodation space or the valve element accommodated in the valve accommodating unit is displaced by a spool accommodated slidably in the spool accommodating unit, the pressure (Pd) of the discharge chamber is applied as the back pressure for controlling the motion of the spool. Accordingly, it is necessary to strictly manage the accommodation space or the clearance between the inner wall of the spool accommodating unit and the spool to reduce leakage of the back pressure, there is inconvenience of high cost.

[0018] In addition, when the accommodation space or the clearance between the inner wall of the spool accommodating unit and the spool is set to a small value, although the leakage of the back pressure can be effectively suppressed, contaminants and the like are easily caught in the accommodation space or the slide contact surface between the inner wall of the spool accommodating unit and the spool and the spool does not operate, possibly causing trouble of the pressure control of the control pressure chamber.

[0019] The invention addresses the above problems with the main object of providing a variable capacity compressor capable of improving the startup performance of the compressor, reducing the amount of refrigerant circulating internally during an intermediate stroke, and eliminating the risk of becoming out of control due to contaminants in the refrigerant or the like.

Solution to Problem

[0020] To achieve the above object, the variable capacity compressor according to the invention including a compression chamber for compressing working fluid, a suction chamber for accommodating the working fluid to be compressed by the compression chamber, a discharge chamber for accommodating the working fluid compressed and discharged by the compression chamber, a control pressure chamber through which a drive shaft penetrates and which accommodates a swash plate rotating as the drive shaft rotates, a supply passage communicating the discharge chamber with the control pressure chamber, and a bleeding passage constantly communicating the control pressure chamber with the suction chamber, the variable capacity compressor changing a discharge capacity by adjusting a pressure of the control pressure chamber, the variable capacity compressor includes an open passage communicating the control pressure chamber with the suction chamber and a valve accommodating chamber formed in the open passage, the open passage having an upstream side open passage communicating the control pressure chamber with the valve accommodating chamber and a downstream side open passage communicating the valve accommodating chamber with the suction chamber, a valve element accommodated in the valve accommodating chamber so as to open and close the downstream side open passage, urging means urging the valve element so as to open the downstream side open passage, a discharge pressure introduction passage that communicates the valve accommodating chamber with the discharge chamber so that a pressure introduced from the discharge chamber to the valve accommodating chamber causes the valve element to close the downstream side open passage, and a check valve provided in the upstream side open passage, the check valve allowing only a flow of the fluid from the control pressure chamber to the valve accommodating chamber.

[0021] As described above, when the compressor stops for a long time and the pressures in the refrigeration cycle are balanced, liquid refrigerant is stored in the control pressure chamber. Since pressures before and after the valve element accommodated in the valve accommodating chamber are balanced, the valve element is urged by the urging means to open the downstream side open passage. When the pressure of the suction chamber becomes lower than the pressure of the control pressure chamber as the compressor starts up, the vaporized refrigerant in the control pressure chamber is exhausted to the suction chamber via the bleeding passage, flowed into the valve accommodating chamber via the upstream side open passage, and is exhausted to the suction chamber from the valve accommodating chamber via the downstream side open passage.

[0022] This enables the refrigerant in the control pressure chamber to immediately escape to the suction chamber and enables reduction in the time until the liquid refrigerant stored in the control pressure chamber is fully vaporized and exhausted to the suction chamber.

[0023] After that, when the suction chamber capacity of the compressor is increased because the pressure of the control pressure chamber is sufficiently reduced, the pressure of the discharge chamber rises, the force applied by the valve element to close the downstream side open passage caused by the difference between the pressure introduced to the valve accommodation chamber via the discharge chamber introduction passage and the pressure of the low pressure chamber exceeds the urging force of the urging means, and the valve element closes the downstream side open passage. In contrast, although the pressure of the valve accommodating chamber is higher than the pressure of the control pressure chamber due to the pressure of the discharge chamber introduced to the valve accommodating chamber via the discharge pressure introduction passage, the upstream side open passage connecting the control pressure chamber to the valve accommodating chamber is provided with a check valve allowing only a flow of the fluid from the control pressure chamber to the valve accommodating chamber. Accordingly, the check valve is closed to break a flow of refrigerant from the discharge pressure introduction passage to the control pressure chamber.

[0024] Accordingly, since the check valve surely prevents the refrigerant having flowed into the valve accommodating chamber via the discharge pressure introduction passage from flowing into the control pressure chamber after the valve element closes the downstream side open passage, it is possible to prevent the occurrence of inconvenience such as trouble of discharge capacity control due to flowing of pressure of the discharge chamber to the control pressure chamber or reduction in performance because of increase in the amount of internal circulating through the compressor.

[0025] Since the check valve for breaking a flow of refrigerant from the discharge pressure introduction passage to the control pressure chamber is provided in addition to the valve element for opening or closing the downstream side open passage as described above, the valve element does not need to include a spool valve and the clearance between the valve element and the valve accommodating chamber does not need to be managed strictly.

[0026] In addition, the disuse of a spool valve also prevents the valve element from becoming out of control due to contaminants in refrigerant or the like. That is, at least in a state in which the valve element closes the downstream side open passage, the valve element does not need to close communication between the portion toward which the discharge pressure introduction passage of the valve accommodating chamber is opened and the portion toward which the upstream side open passage is opened or the valve element does not need to follow a member that slides in the discharge pressure introduction passage (no narrow portion is necessary between the discharge pressure introduction passage and the upstream side open passage or in the discharge pressure introduction passage in the state in which the valve element closes the downstream side open passage), so the motion of the valve element is not easily affected by contaminants or the like.

Advantageous Effects of Invention

[0027] As described above, according to the invention, the variable capacity compressor that adjusts the pressure of control pressure chamber via the supply passage communicating the discharge chamber with the control pressure chamber and the bleeding passage communicating the control pressure chamber with the suction chamber is provided with the valve accommodating chamber connected to the upstream side open passage communicating with the control pressure chamber and the downstream side open passage communicating with the suction chamber, the valve accommodating chamber accommodates the valve element that opens or closes the downstream side open passage and is urged by the urging means so as to open the downstream side open passage, the discharge pressure introduction passage for applying the pressure of the discharge chamber to the valve element so as to close the downstream side open passage is connected to the valve accommodating chamber, and the upstream side open passage is provided with a check valve allowing only a flow of the fluid from the control pressure chamber to the valve accommodating chamber. Accordingly, at the startup time of the compressor when the pressure of the discharge chamber substantially equals the pressure of the suction chamber, the valve element accommodated in the valve accommodating chamber opens the downstream side open passage via the urging means, so the vaporized refrigerant in the control pressure chamber can be immediately exhausted to the suction chamber and the startup performance of the compressor can be improved.

[0028] In addition, when the pressure of the discharge chamber rises and the difference between the pressure of the discharge chamber introduced to the valve accommodating chamber via the discharge chamber introduction passage and the pressure of the low pressure chamber exceeds the urging force of the urging means, the valve element closes the downstream side open passage, the check valve provided in the upstream side open passage is closed, and a flow of refrigerant from the discharge pressure introduction passage to the control pressure chamber can be completely blocked, thereby preventing the occurrence of inconvenience such as trouble of discharge capacity control or reduction in performance because of increase in the amount of refrigerant circulating internally. In addition, since the valve element does not need to have a spool valve, it is possible to prevent the valve element from becoming out of control due to contaminants in refrigerant or the like.

Brief Description of Drawings

[0029]

[Fig. 1] Fig. 1 is a cross sectional view illustrating the compressor according to the invention and illustrates the state of the compressor in the early stage of startup.

[Fig. 2] Fig. 2 is a cross sectional view illustrating the compressor according to the invention and illustrates the state in the full stroke.

[Fig. 3] Fig. 3 is an image view illustrating an open state adjustment mechanism for adjusting the open state of the open passage, Fig. 3 (a) illustrates the state of the compressor in the early stage, and Fig. 3(b) illustrates the state of the compressor that is operating.

[Fig. 4] Fig. 4 illustrates a specific example of the structure of the open state adjustment mechanism for adjusting the open state of the open passage, Fig. 4(a) illustrates the state of the compressor in the early stage, and Fig. 4(b) illustrates the state of the compressor in the intermediate stroke.

[Fig. 5] Fig. 5 is a characteristic diagram illustrating the time transition of the pressure (Pd) of the discharge chamber, the pressure (Pc) of the control pressure chamber, and the pressure (Ps) of the suction chamber of the compressor according to the invention.

[Fig. 6] Fig. 6 illustrates an example of the structure of the differential pressure adjusting valve conventionally proposed for a variable capacity compressor.

[Fig. 7] Fig. 7 illustrates another example of the structure of the differential pressure adjusting valve conventionally proposed for a variable capacity compressor.

Description of Embodiments

[0030] An embodiment of the invention will be described below with reference to the drawings.

[0031] Figs. 1 and 2 illustrate a clutchless type variable capacity compressor driven by a power source such as an engine or the like via a belt. This variable capacity compressor includes a cylinder block 1, a rear head 3 assembled on the rear side (the right side in the drawing) of the cylinder block 1 via a valve plate 2, and a front head 5, assembled so as to block the front side (right side in the drawing) of the cylinder block 1, that defines a control pressure chamber 4. The front head 5, the cylinder block 1, the valve plate 2, and the rear head 3 are tightened in the shaft direction by a tightening bolt 6 and constitute the housing of the compressor.

[0032] A drive shaft 7 penetrates through the control pressure chamber 4 defined by the front head 5 and the cylinder block 1 and one end of the drive shaft 7 projects from the front head 5. A drive pulley 10 rotatably inserted onto a boss part 5a of the front head 5 via a relay member 9 attached in the shaft direction by a bolt 8 is coupled to the part of the drive shaft 7 that projects from the front head 5 so that rotational power is transferred via a drive belt (not illustrated) from the engine of a vehicle. In addition, one end side of the drive shaft 7 is airtightly sealed with respect to the front head 5 via a seal member 11 provided between the drive shaft 7 and the front head 5, and rotatably supported by a radial bearing 12. In addition, the other end side of the drive shaft 7 is rotatably supported by a radial bearing 14 accommodated in an accommodating hole 13 formed substantially at the center of the cylinder block 1.

[0033] In the cylinder block 1, the accommodating hole 13 in which the radial bearing 14 is accommodated and a plurality of cylinder bores 15 disposed at regular intervals in the circumference about the accommodating hole 13 are formed. A single head piston 16 is inserted into each of the cylinder bores 15 so as to slidably reciprocate.

[0034] A thrust flange 17 that rotates together with the drive shaft 7 is fixed to the drive shaft 7 in the control pressure chamber 4. The thrust flange 17 is rotatably supported with respect to the inner surface of the front head 5 via a thrust bearing 18 and a swash plate 20 is coupled to the thrust flange 17 via a link member 19.

[0035] The swash plate 20 is provided tiltably about a hinge ball 21 provided slidably on the drive shaft 7 so as to rotate together with the thrust flange 17 in sync with the rotation of the thrust flange 17 via the link member 19. An engagement part 16a of the single head piston 16 is engaged with the swash plate 20 via a pair of shoes 22 provided at the peripheral edge thereof.

[0036] Therefore, when the drive shaft 7 rotates, the swash plate 20 rotates accordingly, the rotational motion of the swash plate 20 is converted to reciprocal linear motion of the single head piston 16 via the shoes 22, and the capacity of a compression chamber 23 formed between the single head piston 16 and the valve plate 2 is changed in the cylinder bore 15.

[0037] A suction hole 31 and a discharge hole 32 corresponding to the individual cylinder bores 15 are formed in the valve plate 2 and a suction chamber 33 for accommodating working fluid to be compressed in the compression chamber 23 and a discharge chamber 34 for accommodating working fluid compressed and discharged in the compression chamber 23 are defined in the rear head 3. The suction chamber 33 is formed at the center of the rear head 3, communicates with a suction port (not illustrated) leading to the exit side of the evaporator, and is communicable with the compression chamber 23 via the suction hole 31 opened or closed by a suction valve (not illustrated). In addition, the discharge chamber 34 is formed around the suction chamber 33, is communicable with the compression chamber 23 via the discharge hole 32 opened or closed by a discharge valve (not illustrated), and communicates with a discharge space 37 formed around the cylinder block 1 via passages 2a and 1a formed in the valve plate 2 and the cylinder block 1. This discharge space 37 is defined by the cylinder block 1 and a cover 38 attached thereto, the cover 38 is provided with an exit port 39 leading to the entry side of the condenser, and provided with a check valve 36 for preventing the backward flow of refrigerant from the condenser to the discharge space 37.

[0038] The discharge amount of the compressor is determined by the stroke of the piston 16 and the stroke is determined by the tilt angle of the swash plate 20 with respect to the surface orthogonal to the drive shaft 7. The tilt angle of the swash plate 20 is balanced at the angle at which the sum the following moments equals zero: the moment derived from the pressure difference between the pressures (the pressure within the cylinder bore) of the compression chambers 23 applied to the individual pistons 16 and the pressures of the control pressure chambers 4, the moment derived from the inertial forces of the swash plates and the pistons, and the moment derived from the urging force by a destroke spring 24 urging the hinge ball 21. This determines the piston stroke and determines the discharge capacity.

[0039] That is, since the pressure difference between the compression chamber 23 and the control pressure chamber 4 is increased when the pressure of the control pressure chamber 4 is reduced, moment acts in the direction in which the tilt angle of the swash plate 20 is increased. Accordingly, when the tilt angle of the swash plate 20 is increased as illustrated in Fig. 2, the hinge ball 21 moves toward the thrust flange against an urging force from the destroke spring 24, the stroke amount of the piston 16 is increased, and the discharge amount is increased.

[0040] In contrast, when the pressure of the control pressure chamber 4 is increased and the pressure difference between the compression chamber 23 and the control pressure chamber 4 is reduced, moment acts in the direction in which the tilt angle of the swash plate 20 is reduced. Accordingly, the tilt angle of the swash plate 20 is reduced as illustrated in Fig. 1, the hinge ball 21 moves away from the thrust flange 17, the stroke amount of the piston 16 is reduced, and the discharge capacity is reduced.

[0041] In this structure example, a supply passage 40 through which the discharge chamber 34 communicates with the control pressure chamber 4 is formed by passages 1b, 2b, and 3b formed across the cylinder block 1, the valve plate 2, and the rear head 3. In addition, a bleeding passage 41 is formed through which the control pressure chamber 4 communicates with the suction chamber 33 via the accommodating hole 13 formed in the cylinder block 1, an orifice hole 2c formed in the valve plate 2, a passage 7c formed in the drive shaft 7, clearance of the radial bearing 14, and the like. In addition, a pressure control valve 42 is provided on the supply passage 40 and the pressure control valve 42 controls the pressure of the control pressure chamber 4 by adjusting the flow rate of refrigerant flowing from the discharge chamber 34 to the control pressure chamber 4.

[0042] The pressure control valve 42 is inserted and mounted to a mount hole 43 formed in the rear head 3, controls the pressure of the control pressure chamber by adjusting the opening of the supply passage 40 so that the suction pressure becomes the target value, fully opens the supply passage 40 by turning off energization, minimizes the discharge capacity by increasing the pressure of the control pressure chamber, and makes other control.

[0043] Accordingly, when energization to the pressure control valve 42 is stopped in the state in which the compressor is rotated and driven, the refrigerant discharged to the discharge chamber 34 from the compression chamber 23 circulates through an internal circulation route in the compressor that sequentially connects the discharge chamber 34, the pressure control valve 42, the supply passage 40, the control pressure chamber 4, the bleeding passage 41, the suction chamber 33, the suction hole 31, the compression chamber 23, the discharge hole 32, and the discharge chamber 34. The refrigerant gas circulating through the internal circulation route cools and rubricates sliding parts in the compressor.

[0044] Such a compressor is provided with an open passage 50 communicating the control pressure chamber 4 with the suction chamber 33. In this example, one end of this open passage 50 is connected to a passage 1c (upstream of the orifice hole of the bleeding passage 41) formed in the cylinder block 1 and the other end is connected to the suction chamber 33 via the valve plate 2.

[0045] Accordingly, although the control pressure chamber 4 communicating with the suction chamber 33 via the open passage 50 includes the case in which one end of the open passage 50 is connected to the space to which the pressure of the control pressure chamber 4 is reflected as is, the part to which one end of the open passage 50 is connected is assumed to be the control pressure chamber 4 in the following description.

[0046] This open passage 50 is provided with an open state adjustment mechanism for automatically adjusting the opening state of this passage.

[0047] In this open state adjustment mechanism, a valve accommodating chamber 51 is formed in the open passage 50, the part of the open passage 50 in which the control pressure chamber 4 communicates with the valve accommodating chamber 51 is an upstream side open passage 50a, the part of the open passage 50 in which the valve accommodating chamber 51 communicates with the suction chamber 33 is a downstream side open passage 50b, the valve accommodating chamber 51 accommodates a valve element 52 for opening or closing the downstream side open passage 50b, and the valve element 52 is constantly urged by a spring 53 (urging means) so as to open the downstream side open passage 50b.

[0048] In addition, a discharge pressure introduction passage 54 is connected to the valve accommodating chamber 51. The discharge pressure introduction passage 54 communicates with the discharge chamber 34 and applies, to the valve element, the pressure introduced to the valve accommodating chamber 51 from the discharge chamber 34 so as to close the downstream side open passage 50b. This valve element 52 has a shape (that is, a shape in which there is no narrow portion between the discharge pressure introduction passage 54 of the valve accommodating chamber 51 and the upstream side open passage 50a) that does not close the part between the part of the valve accommodating chamber 51 toward which the discharge pressure introduction passage 54 is opened and the part toward which the upstream side open passage 50a is opened in the state in which the downstream side open passage 50b is closed.

[0049] In addition, the upstream side open passage 50a is provided with a check valve 55 allowing only a flow of the fluid from the control pressure chamber 4 (the passage 1c formed in the cylinder block 1) to the valve accommodating chamber 51.

[0050] Accordingly, when the force applied to the valve element 52 by the pressure difference between the discharge chamber 34 and the suction chamber 33 is less than the urging force of the spring 53, the valve element 52 is moved by the urging force of the spring 53 to the position in which the downstream side open passage 50b is opened. When the pressure of the control pressure chamber 4 is larger than the pressure of the suction chamber 33 in this state, the check valve 55 is opened and the pressure in the control pressure chamber 4 is exhausted from the upstream side open passage 50a to the suction chamber 33 via the valve accommodating chamber 51 and the downstream side open passage 50b.

[0051] In addition, when the pressure difference between the discharge chamber 34 and the suction chamber 33 is larger than the urging force of the spring 53, the pressure of the discharge chamber 34 introduced to the valve accommodating chamber 51 via the discharge pressure introduction passage 54 causes the valve element 52 to close the downstream side open passage 50b. In addition, since the pressure of the discharge chamber 34 is also transmitted to the upstream side open passage 50a via the valve accommodating chamber 51, the check valve 55 provided in the upstream side open passage 50a is closed. Accordingly, a flow of refrigerant (pressure) from the control pressure chamber 4 to the suction chamber 33 is blocked and the refrigerant (pressure) having flowed into the valve accommodating chamber 51 from the discharge chamber 34 via the discharge pressure introduction passage 54 does not flow into the control pressure chamber 4 via the upstream side open passage 50a.

[0052] The above open state adjustment mechanism can have various specific structures and may have, for example, the structure illustrated in Fig. 4.

[0053] In this example, a valve holder 61 is mounted in a holder mount hole 60 formed in the cylinder block 1, the valve accommodating chamber 51 surrounded by the valve holder 61 and a lid body 62 screwed with the valve holder 61 is formed in the valve holder 61, a relay space 63 for attaching the check valve 55 is formed adjacently to the holder mount hole 60, the relay space 63 is communicated with the valve accommodating chamber 51 via a side hole 68 formed in a holder body 61a, and the relay space 63 is communicated with the passage 1c communicating with the control pressure chamber 4 via a communication path 64. The communication path 64, the relay space 63, and the side hole 68 formed in the valve holder constitute the upstream side open passage 50a communicating the control pressure chamber 4 (passage 1c) with the valve accommodating chamber 51.

[0054] In addition, a high pressure introduction space 60a is formed in the part of the holder mount hole 60 close to the insertion end of the valve holder 61 and the high pressure introduction space 60a communicates with a high pressure communication path 65 communicating with the discharge chamber 34.

[0055] In addition, the valve holder 61 is provided with a first shaft hole 66 connected to a passing hole 2d that has one end connected to the valve accommodating chamber 51 and the other end formed in the valve plate 2 and opened toward the suction chamber 33. In addition, the valve holder 61 is provided with a second shaft hole 67 having one end connected to the valve accommodating chamber 51 and the other end connected to the high pressure introduction space 60a.

[0056] The first shaft hole 66 and the passing hole 2d constitute the downstream side open passage 50b, and the second shaft hole 67, the holder mount hole 60, and the high pressure communication path 65 constitute the discharge pressure introduction passage 54.

[0057] The valve accommodating chamber 51 accommodates the valve element 52 formed as, for example, a steel ball. The valve element 52 is accommodated in the valve accommodating chamber 51 so as to open or close the downstream side open passage 50b and urged by the spring 53 held by the valve holder 61 so as to release the downstream side open passage 50b.

[0058] In addition, the check valve 55 provided in the upstream side open passage is provided in the communication path 64 communicating the relay space 63 with the passage 1c leading to the control pressure chamber 4 and formed as, for example, a steel ball. The check valve 55 formed as a steel ball seats on a base provided in an intermediate part of the communication path 64 from the relay space 63 to close the upstream side open passage. In contrast, when the check valve 55 opens the upstream side open passage, the lift amount is restricted by a pin 69 fixed to the cylinder block so as to project to the relay space to prevent a drop.

[0059] In the above structure, in the state in which the compressor stops for a long time, the pressure of the discharge chamber 34, the pressure of the control pressure chamber 4, and the pressure of the suction chamber 33 are substantially the same, the pressure control valve 42 is fully opened because energization is stopped (off), and the tilt angle of the swash plate 20 with respect to the surface orthogonal to the drive shaft 7 is small.

[0060] When the engine is turned on in this state, the compressor starts rotating in the state in which energization to the pressure control valve 42 is stopped and the piston starts operating in the minimum stroke. Accordingly, although the amount of refrigerant much enough to internally circulating through the compressor is discharged to the discharge chamber, this amount is insufficient to push and open the check valve 36 provided in the discharge space 37. Therefore, the refrigerant is not supplied to the external cycle.

[0061] In this state, as illustrated in Fig. 5, from time t0 when the engine is turned on, the pressure (suction pressure Ps) in the suction chamber 33 becomes slightly lower than when the engine stops, the pressure (discharge pressure Pd) of the discharge chamber 34 becomes slightly higher than when the engine stops, and the pressure (Pc) of the control pressure chamber 4 also becomes slightly higher because the pressure control valve 42 is fully opened.

[0062] After that, when the external cycle starts up and energization to the pressure control valve 42 starts (time t1), the supply passage 40 is closed, the supply of the pressure from the compression chamber 34 to the control pressure chamber 4 stops, and the discharge chamber pressure Pd rises accordingly. Although the supply of the pressure from the discharge chamber 34 to the control pressure chamber 4 stops at this time, since the liquid refrigerant stored in the control pressure chamber 4 continues to vaporize, the pressure in the control pressure chamber 4 is kept without being reduced.

[0063] Since the difference between the discharge chamber pressure (Pd) and the suction chamber pressure (Ps) is small in the early stage of startup, it is possible to keep the valve element 52 in the position in which the downstream side open passage 50b is opened using the urging force of the spring 53. In addition, since the pressure of the control pressure chamber is higher than the pressure of the suction chamber, the check valve 55 is opened, the vaporized refrigerant in the control pressure chamber 4 flows into the valve accommodating chamber 51 through the upstream side open passage 50 and flows from the valve accommodating chamber 51 into the suction chamber 33.

[0064] Accordingly, even while the liquid refrigerant stored in the control pressure chamber 4 vaporizes, since the vaporized refrigerant continues to flow into the suction chamber 33 via the open passage 50 in addition to the bleeding passage 41 via the orifice 2c, the pressure in the control pressure chamber 4 can immediately escape to the suction chamber, the pressure in the control pressure chamber 4 reduces, and time T until the compressor starts operating can be shortened.

[0065] Insidentaly, if the urging force of the spring 53 is set too small, since the valve element 52 is closed before the liquid refrigerant is fully vaporized and the pressure in the control pressure chamber 4 is reduced sufficiently, the startup of the compressor cannot be hastened sufficiently. In contrast, if the urging force is set too large, since the force applied to the valve element 52 according to the difference between the pressure in the discharge chamber and the pressure in the suction chamber becomes lower than the urging force of the spring and when the compressor normally operates under low loads, the valve element 52 is opened, the pressure in the control pressure chamber does not rise, and the valve element 52 may become out of control. Accordingly, the urging force of the spring 53 is preferably set to a value larger than value (α) applied to the valve element according to the difference between the pressure in the discharge chamber and the pressure in the suction chamber when the liquid refrigerant stored in the control pressure chamber 4 continues to vaporize in consideration of the time necessary for substantially all of the liquid refrigerant stored in the control pressure chamber 4 to vaporize and be released to the suction chamber 33 via the open passage 50, and smaller than value (β) applied to the valve element according to the difference between the pressure in the discharge chamber and the pressure in the suction chamber during low load operation.

[0066] After that, the pressure of the discharge chamber 34 rises because the discharge capacity of the compressor becomes large, the difference between the pressure in the discharge chamber 34 introduced to the valve accommodating chamber via the discharge chamber introduction passage and the pressure in the suction chamber 33 exceeds the urging force of the spring 53 and the downstream side open passage 50b is closed by the valve element 52. At the same time, since the pressure in the discharge chamber 34 tries to flow into the control pressure chamber 4 via the upstream side open passage 50a, the check valve 55 is closed, thereby completely blocking a flow of refrigerant from the discharge chamber 34 to the suction chamber 33 and the control pressure chamber 4.

[0067] Accordingly, even if the valve element 52 is not configured like a spool valve, since there is not risk of causing the refrigerant of the discharge chamber 34 to flow into the control pressure chamber 4 after the downstream side open passage 50b is closed by the valve element 52, inconvenience such as losses of discharge capacity control is not caused by a flow of the pressure in the discharge chamber 34 into the control pressure chamber 4. In addition, since a flow of refrigerant from the discharge chamber 34 to the control pressure chamber 4 can be surely blocked, it is possible to prevent occurrence of inconvenience of reduction in performance due to increase in the amount of refrigerant circulating internally.

[0068] In addition, since a spool valve does not need to be used as the valve element 52 in the above structure, the operation of the valve element is not affected by contaminants in refrigerant or the like, thereby eliminating the risk of becoming out of control.

[0069] Although, in Figs. 3(a) and 4(a), the valve element 52 closes the discharge pressure introduction passage 54 in the state in which the valve element 52 releases the downstream side open passage 50b, the invention is not limited to this example as long as the part of the discharge pressure introduction passage 54 opened toward the valve accommodating chamber 51 is configured so that the discharge pressure introduced from the discharge chamber to the valve accommodating chamber 51 is applied so as to cause the valve element 52 to close the downstream side open passage 50b.

Reference Signs List

[0070]

4: control pressure chamber
7: drive shaft
20: swash plate
33: suction chamber
34: discharge chamber
40: air supply passage
41: air bleeding passage
50: open passage
50a: upstream side open passage
50b: downstream side open passage
51: valve accommodating chamber
52: valve element
53: spring
54: discharge pressure introduction passage
55: check valve

Claims

1. A variable capacity compressor comprising a compression chamber (23) for compressing working fluid, a suction chamber (33) for accommodating the working fluid to be compressed by the compression chamber (23), a discharge chamber (34) for accommodating the working fluid compressed and discharged by the compression chamber (23), a control pressure chamber (4) through which a drive shaft (7) penetrates and which accommodates a swash plate (20) rotating as the drive shaft (7) rotates, a supply passage (40) communicating the discharge chamber (34) with the control pressure chamber (4), and a bleeding passage (41) constantly communicating the control pressure chamber (4) with the suction chamber (33), the variable capacity compressor changing a discharge capacity by adjusting a pressure of the control pressure chamber (4), **charac-**

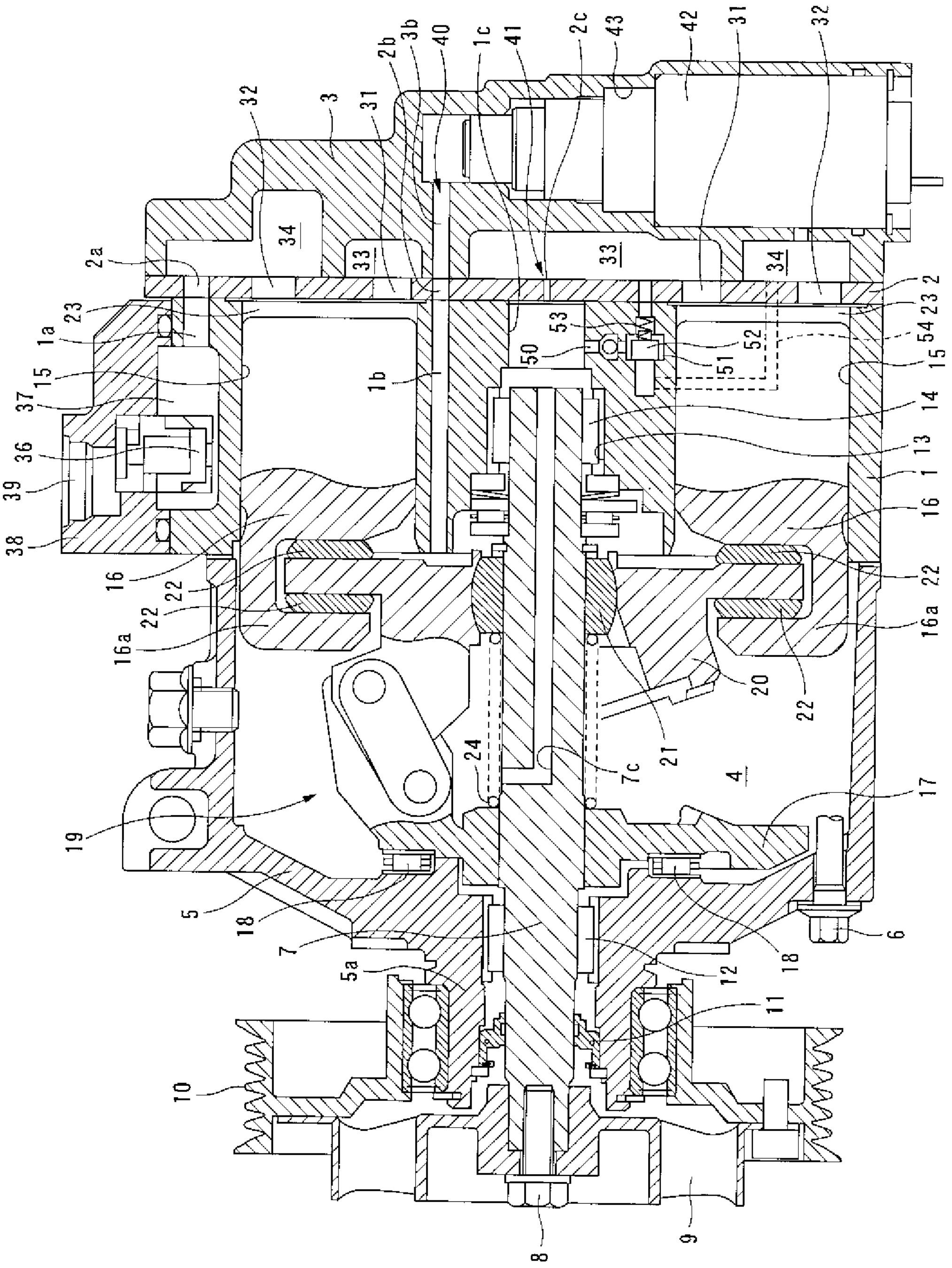
terized in that the variable capacity compressor comprises:

an open passage (50) communicating the control pressure chamber (4) with the suction chamber (33); and
a valve accommodating chamber (51) formed in the open passage (50), the open passage (50) having an upstream side open passage (50a) communicating the control pressure chamber (4) with the valve accommodating chamber (51) and a downstream side open passage (50b) communicating the valve accommodating chamber (51) with the suction chamber (33);
a valve element (52) accommodated in the valve accommodating chamber (51) so as to open and close the downstream side open passage (50b);
urging means (53) urging the valve element (52) so as to open the downstream side open passage (50b);
a discharge pressure introduction passage (54) that communicates the valve accommodating chamber (51) with the discharge chamber (34) so that a pressure introduced from the discharge chamber (34) to the valve accommodating chamber (51) causes the valve element (52) to close the downstream side open passage (50b); and
a check valve (55) provided in the upstream side open passage (50a), the check valve (55) allowing only a flow of the fluid from the control pressure chamber (4) to the valve accommodating chamber (51).

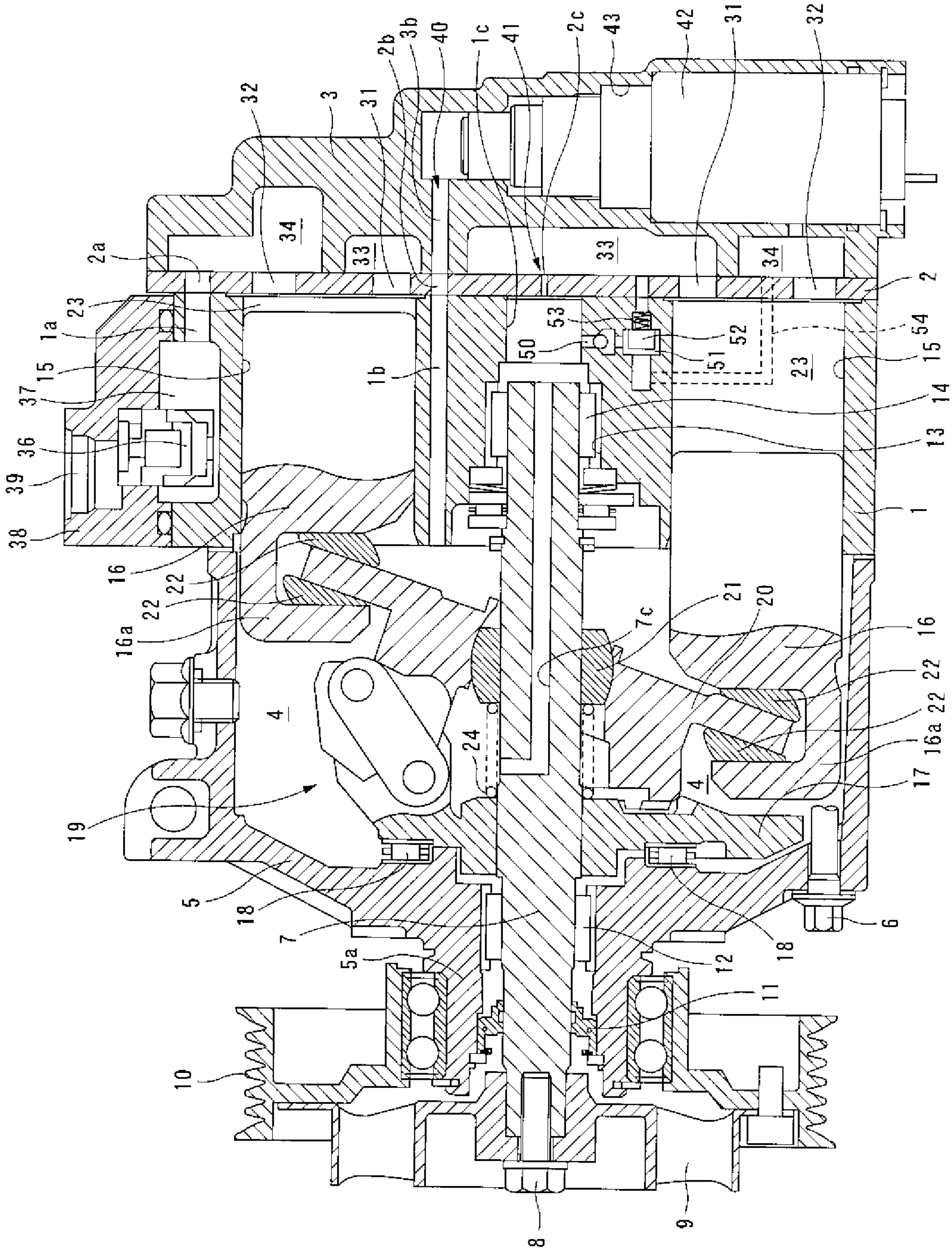
2. The variable capacity compressor according to claim 1,
wherein the valve element (52) does not block communication between a portion toward which the discharge pressure introduction passage (54) (51) is opened in the valve accommodating chamber (51) and a portion toward which the upstream side open passage (50a) is opened in the valve accommodating chamber (51) at least in a state in which the valve element (52) closes the downstream side open passage (50b).

3. The variable capacity compressor according to claim 1,
wherein the valve element (52) does not follow a member that slides in the discharge pressure introduction passage (54).

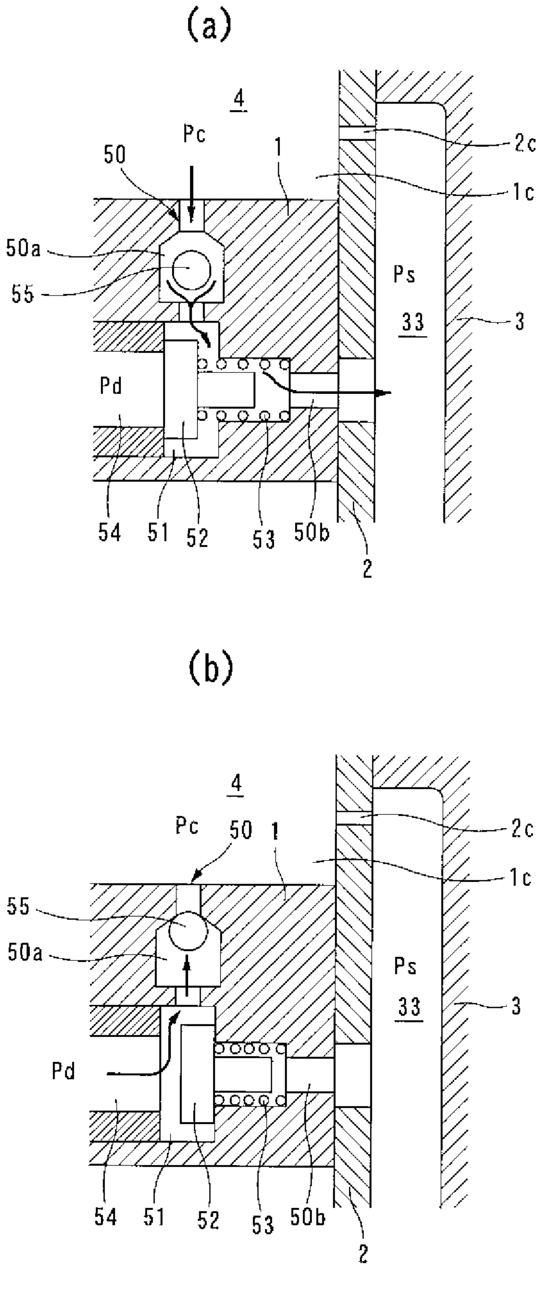
[FIG.1]


32
3
31
2b
3b
40
1c
41
2c
43
42
31
32
2a
34
33
33
34
2
23
1a
23
15
37
36
39
38
1b
50
53
52
51
54
15
14
13
1
16
16
22
22
16a
22
22
16a
20
22
21
7c
24
4
17
19
5
18
7
5a
6
18
12
11
10
8
9

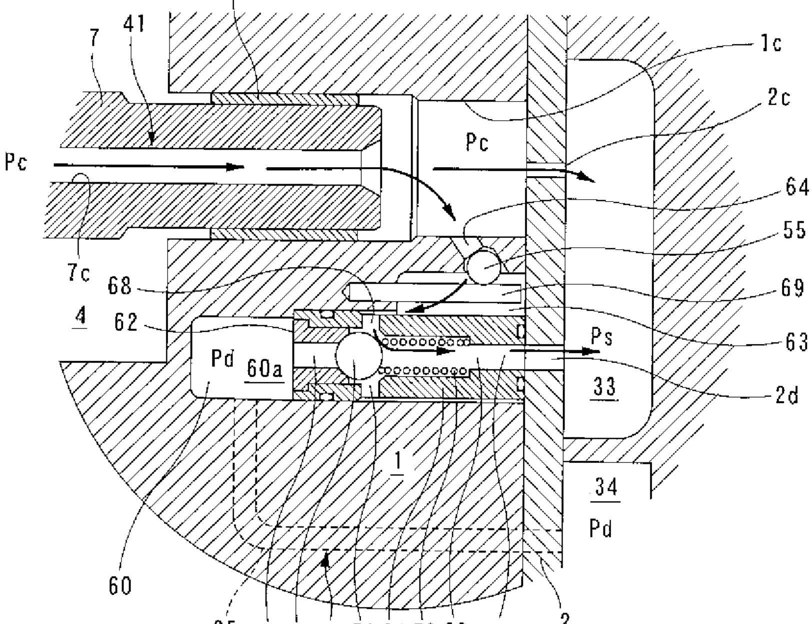
[FIG.2]

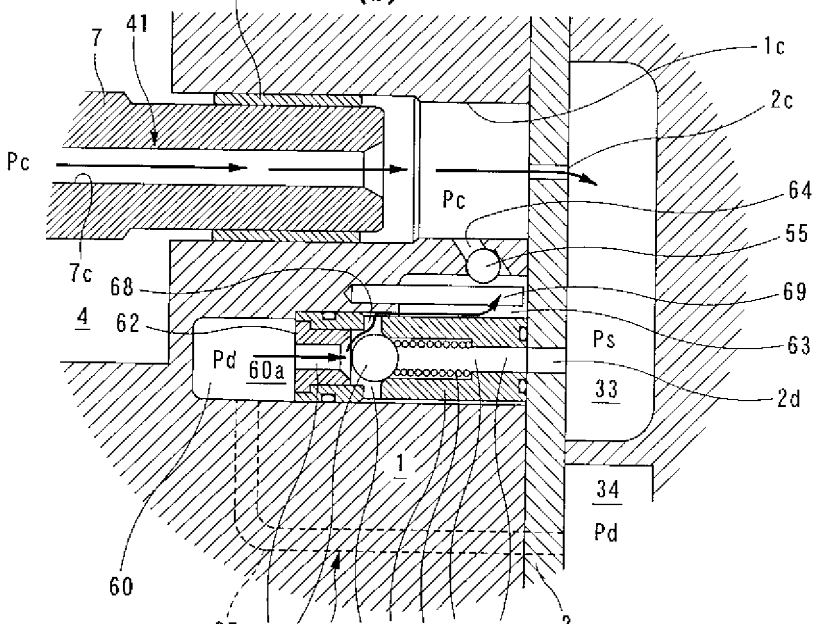


[FIG.3]

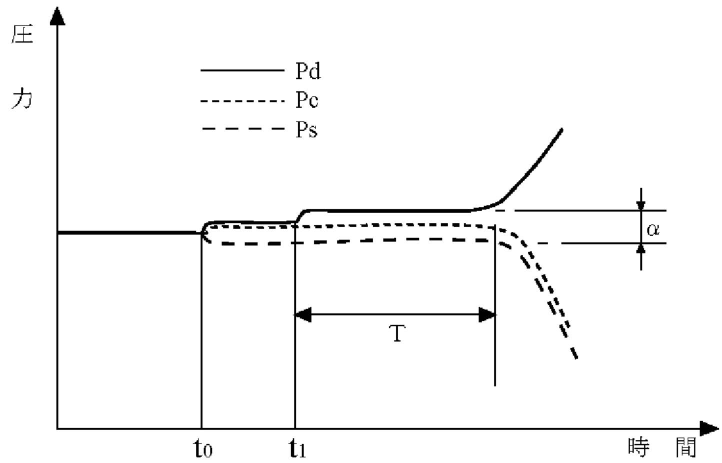

(a)
4
Pc
50
1
2c
1c
50a
55
Ps
33
3
Pd
54
51
52
53
50b
2
(b)
4
Pc
50
1
2c
1c
55
50a
Ps
33
3
Pd
54
51
52
53
50b
2

[FIG.4]

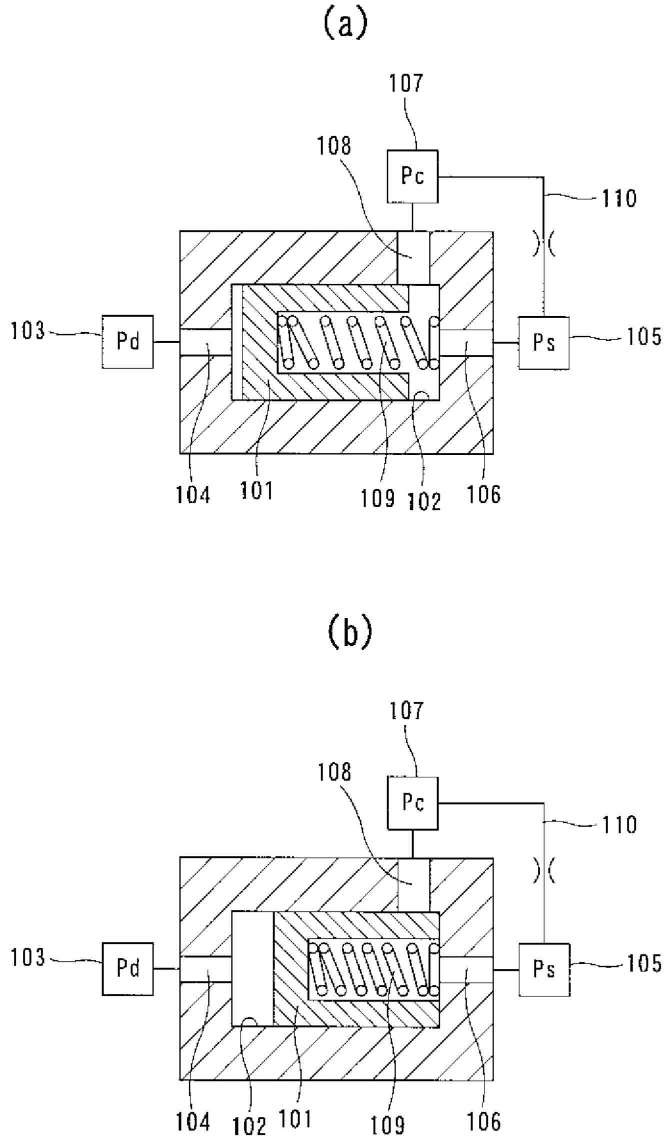

(a)
14
7
41
1c
2c
Pc
Pc
64
55
7c
68
69
4
62
63
Pd
60a
Ps
2d
33
1
34
Pd
60
65
67
52
54
51
61
53
66
50b
2


(b)
14
7
41
1c
2c
Pc
Pc
64
55
7c
68
69
4
62
63
Pd
60a
Ps
33
2d
1
34
Pd
60
65
67
52
54
51
61
53
66
50b
2

[FIG.5]

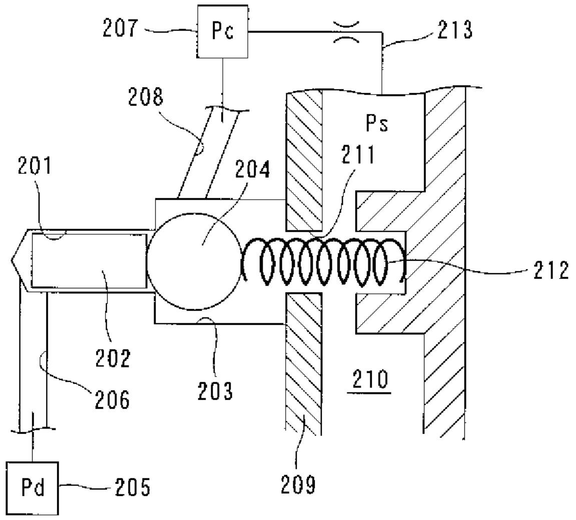


[FIG.6]

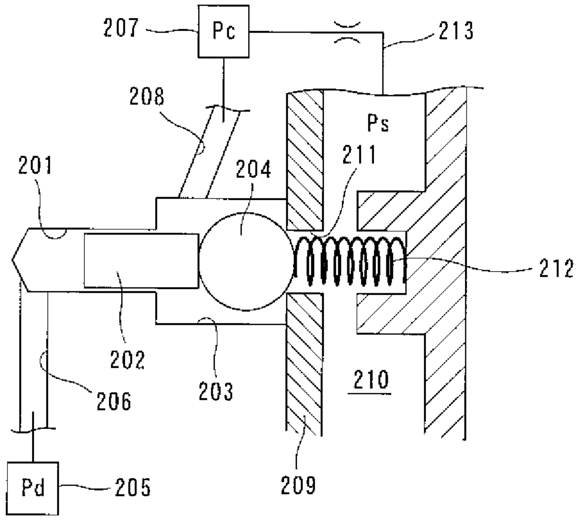

(a)
107
108
Pc
110
103
Pd
Ps
105
104
101
109
102
106
(b)
107
108
Pc
110
103
Pd
Ps
105
104
102
101
109
106

[FIG.7]

(a)


207
Pc
213
208
Ps
211
201
204
212
202
203
210
206
209
Pd
205

(b)


207
Pc
213
208
Ps
211
201
204
212
202
203
210
206
209
Pd
205

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/085259

A. CLASSIFICATION OF SUBJECT MATTER
F04B27/18(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B25/00-37/20, 41/00-41/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/061304 A1 (Zexel Valeo Climate Control Corp.), 22 July 2004 (22.07.2004), page 9, line 10 to page 13, line 15; page 19, line 4 to page 22, line 9; fig. 2 to 3, 8 to 9 & JP 4501112 B2 & EP 1586772 A1 paragraphs [0026] to [0038], [0052] to [0059]; fig. 2 to 3, 8 to 9	1-3
A	JP 2002-21721 A (Toyota Industries Corp.), 23 January 2002 (23.01.2002), paragraphs [0061] to [0066]; fig. 1, 4 & US 2002/0006337 A1 paragraphs [0057] to [0062]; fig. 1, 4 & EP 1172559 A2 & DE 60108009 T2 & BR 103464 A & KR 10-2002-0005405 A & CN 1333430 A	1-3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2016 (23.02.16)	01 March 2016 (01.03.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/085259

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 10-205443 A (Sanden Corp.), 04 August 1998 (04.08.1998), paragraph [0020]; fig. 1 & EP 855506 A2 column 4, line 57 to column 5, line 37; fig. 1 & DE 69802444 T2	1-3

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 4501112 B **[0016]**