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(54) REFRIGERATION CYCLE DEVICE

(57) A refrigeration cycle apparatus 100 includes a volume control compressor 101, a volume control path 111, a four-way valve 112 (flow path switching unit), a high-pressure introduction path 114, a low-pressure introduction path 116, and a check valve 120. When the load is small, the four-way valve 112 is controlled so as to connect the volume control path 111 to the low-pressure introduction path 116. When the load is large, the four-way valve 112 is controlled so as to connect the volume control path 111 to the high-pressure introduction path 114. The high-pressure introduction path 114 is provided with the check valve 120 that permits a flow of a refrigerant in a direction from the flow path 10a to the four-way valve 112 and that precludes a flow in the opposite direction.

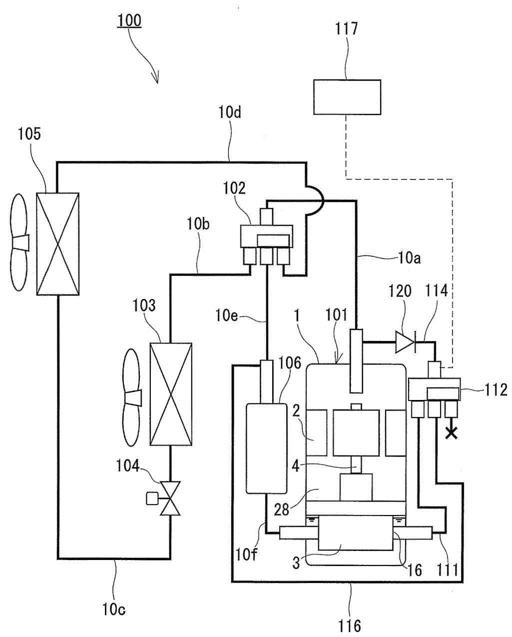

FIG.1

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Description

TECHNICAL FIELD

[0001] The present invention relates to refrigeration cycle apparatuses. The present invention particularly relates to a refrigeration cycle apparatus including a volume control compressor.

BACKGROUND ART

[0002] Volume control compressors capable of varying the suction volume (displacement volume) have been conventionally known. Although volume control techniques for compressors had been vigorously studied before widespread use of inverters, the importance of the volume control techniques was temporarily reduced after high-performance inverters have become cheaply available. Nowadays, however, the volume control techniques for compressors are beginning to receive renewed attention in an attempt to achieve further energy saving. One example of the volume control techniques will be presented with reference to FIG. 9.

[0003] FIG. 9 is a configuration diagram of an air conditioner described in Patent Literature 1. The air conditioner 600 includes a volume control compressor 622, a four-way valve 623, an outdoor heat exchanger 624, an expansion means 625, an indoor heat exchanger 641, an accumulator 621, a bypass pipe 688, a flow path switching valve 690, a suction pipe 628, and a discharge pipe 630. A bypass discharge valve (not shown) is provided at a connecting portion between the volume control compressor 622 and the bypass pipe 688.

[0004] When the air-conditioning load is small, the bypass pipe 688 is connected to the suction pipe 628 by the flow path switching valve 690. Consequently, a part of the drawn refrigerant is returned to the suction pipe 628 through the bypass pipe 688, and a low-volume operation is enabled. On the other hand, when the air-conditioning load is large, the bypass pipe 688 is connected to the discharge pipe 630 by the flow path switching valve 690. At this time, the bypass discharge valve is closed by the refrigerant having a discharge pressure.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: JP 2008-240699 A

SUMMARY OF INVENTION

Technical Problem

[0006] In the case where the volume control described with reference to FIG. 9 is employed, there is a risk that a large amount of oil flows out of the compressor.

[0007] The present invention is intended to solve such a problem, and aims to provide a refrigeration cycle apparatus that allows reduction in the amount of an oil flowing out of a volume control compressor and that can exhibit high machine efficiency (COP (coefficient of performance) of the refrigeration cycle).

Solution to Problem

[0008] That is, the present disclosure provides a refrigeration cycle apparatus including:

a volume control compressor including a compression chamber, a bypass discharge port opening into the compression chamber, and a bypass discharge valve that opens and closes the bypass discharge port, the volume control compressor being capable of varying a suction volume by discharging a refrigerant, which is drawn into the compression chamber, from the compression chamber through the bypass discharge port while maintaining the refrigerant at a suction pressure;
a radiator that cools the refrigerant compressed by the compressor;
an expansion mechanism that expands the refrigerant cooled by the radiator;
an evaporator that heats the refrigerant expanded by the expansion mechanism;
a suction path that directs the refrigerant to be compressed from the evaporator to the compression chamber;
a discharge path that directs the compressed refrigerant from the compression chamber to the radiator;
a volume control path connected to the bypass discharge port;
a flow path switching unit that supplies either a discharge pressure of the compressor or the suction pressure of the compressor as a control pressure to the volume control path;
a high-pressure introduction path having one end connected to the flow path switching unit and another end connected to the discharge path;
a low-pressure introduction path having one end connected to the flow path switching unit and another end connected to the suction path;
a controller that controls the flow path switching unit so as to connect the volume control path to the low-pressure introduction path when a load on the refrigeration cycle apparatus is small, and that controls the flow path switching unit so as to connect the volume control path to the high-pressure introduction path when the load is large; and
a check valve provided on the high-pressure introduction path, the check valve being configured to permit a flow of the refrigerant in a direction from the discharge path to the flow path switching unit and preclude a flow in an opposite direction.

Advantageous Effects of Invention

[0009] According to the refrigeration cycle apparatus of the present disclosure, the high-pressure introduction path is provided with the check valve. Therefore, even when a high internal pressure of the compression chamber acts on the bypass discharge port, the internal pressure of the compression chamber is blocked by the check valve. Since the volume control path is filled with the refrigerant having a pressure equal to the internal pressure of the compression chamber, the bypass discharge valve is also closed. Therefore, excessive discharge of an oil to the refrigeration circuit can be prevented. As a result, heat transfer in the heat exchanger is improved, and the pressure loss which occurs when the refrigerant passes through the pipes is reduced, so that the coefficient of performance (COP) of the refrigeration cycle is increased.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a configuration diagram of a refrigeration cycle apparatus according to an embodiment 1 of the present invention.
FIG. 2 is a schematic transverse cross-sectional view of a volume control compressor used in the refrigeration cycle apparatus of FIG. 1.
FIG. 3 is a configuration diagram illustrating the operation of the refrigeration cycle apparatus of FIG. 1 in a low volume mode.
FIG. 4 is a configuration diagram of a refrigeration cycle apparatus according to a modification 1.
FIG. 5 is a configuration diagram of a refrigeration cycle apparatus according to a modification 2.
FIG. 6 is a schematic longitudinal cross-sectional view of a volume control compressor used in the refrigeration cycle apparatus of FIG. 5.
FIG. 7 is a configuration diagram of a refrigeration cycle apparatus according to an embodiment 2 of the present invention.
FIG. 8 is a configuration diagram of a refrigeration cycle apparatus according to a modification 3.
FIG. 9 is a configuration diagram of a conventional air conditioner.

DESCRIPTION OF EMBODIMENTS

[0011] Problems with the conventional volume control will be described in detail. It is predicted that the problems as discussed below arise in the case where the volume control described with reference to FIG. 9 is employed. For example, in the case where the position of the bypass discharge valve is close to the discharge port of the compression chamber, there is a possibility that the pressure acting on the bypass discharge valve (the internal pressure of the compression chamber) exceeds the discharge pressure. This is because a pressure loss occurs in the path from the compression chamber to the discharge pipe. Therefore, the internal pressure of the compression chamber is higher than the discharge pressure by the amount of the pressure loss. When the internal pressure of the compression chamber which acts on the bypass discharge valve exceeds the discharge pressure, the bypass discharge valve cannot be kept closed.

[0012] In the case where the bypass discharge valve cannot be kept closed, a large amount of oil flows into the discharge pipe through the bypass pipe, and the amount of the oil circulating in the refrigeration circuit is increased. The large amount of oil having flowed out of the compressor inhibits heat transfer in the heat exchanger, and increases the amount of the pressure loss which occurs when the refrigerant passes through the pipes, leading to reduction in the efficiency of the refrigeration cycle. This problem can be solved by the following disclosure.

[0013] A first aspect of the present disclosure provides a refrigeration cycle apparatus including:

a volume control compressor including a compression chamber, a bypass discharge port opening into the compression chamber, and a bypass discharge valve that opens and closes the bypass discharge port, the volume control compressor being capable of varying a suction volume by discharging a refrigerant, which is drawn into the compression chamber, from the compression chamber through the bypass discharge port while maintaining the refrigerant at a suction pressure;
a radiator that cools the refrigerant compressed by the compressor;
an expansion mechanism that expands the refrigerant cooled by the radiator;
an evaporator that heats the refrigerant expanded by the expansion mechanism;
a suction path that directs the refrigerant to be compressed from the evaporator to the compression chamber;
a discharge path that directs the compressed refrigerant from the compression chamber to the radiator;
a volume control path connected to the bypass discharge port;
a flow path switching unit that supplies either a discharge pressure of the compressor or the suction pressure of the compressor as a control pressure to the volume control path;
a high-pressure introduction path having one end connected to the flow path switching unit and another end connected to the discharge path;
a low-pressure introduction path having one end connected to the flow path switching unit and another end connected to the suction path;
a controller that controls the flow path switching unit so as to connect the volume control path to the low-pressure introduction path when a load on the refrig-

eration cycle apparatus is small, and that controls the flow path switching unit so as to connect the volume control path to the high-pressure introduction path when the load is large; and

a check valve provided on the high-pressure introduction path, the check valve being configured to permit a flow of the refrigerant in a direction from the discharge path to the flow path switching unit and preclude a flow in an opposite direction.

[0014] A second aspect provides the refrigeration cycle apparatus as set forth in the first aspect, wherein the compressor may further include a suction port and a discharge port. When the load is small, a part of the refrigerant drawn into the compression chamber through the suction port can be discharged from the compression chamber through the bypass discharge port while maintaining the suction pressure, and a remaining part of the refrigerant drawn into the compression chamber through the suction port can be compressed in the compression chamber, and then discharged from the compression chamber through the discharge port. The refrigerant discharged from the compression chamber through the bypass discharge port is returned to the suction path. Therefore, unnecessary compression work is not performed by the compressor.

[0015] A third aspect provides the refrigeration cycle apparatus as set forth in the first or second aspect, wherein the refrigeration cycle apparatus may further include a relief valve circuit. The high-pressure introduction path may have a first portion between the check valve and the flow path switching unit, and a second portion between the check valve and the discharge path. The relief valve circuit may have one end connected to the first portion and another end connected to the second portion or the discharge path. With the relief valve circuit, excessive increase in pressure in the volume control path, the flow path switching unit, and the first portion of the high-pressure introduction path, can be prevented by diverting the pressure to the second portion or the discharge path.

[0016] A fourth aspect provides the refrigeration cycle apparatus as set forth in the first aspect, wherein the compressor may be a hermetic multicylinder compressor further including: a first compression chamber as the compression chamber and a second compression chamber; a closed casing having an internal space capable of retaining the refrigerant compressed in the first compression chamber and the refrigerant compressed in the second compression chamber; an intermediate chamber that receives the refrigerant discharged from the first compression chamber through the bypass discharge port; a first discharge port that allows communication between the intermediate chamber and the internal space of the closed casing; and a first discharge valve that opens and closes the first discharge port. The volume control path can be connected to the bypass discharge port via the intermediate chamber. When the load is small, the refrigerant drawn into the first compression chamber can be discharged from the first compression chamber through the bypass discharge port while maintaining the suction pressure, and can be returned to the suction path through the intermediate chamber, the volume control path, and the low-pressure introduction path. When the load is large, the refrigerant drawn into the first compression chamber can be compressed in the first compression chamber to a pressure higher than the discharge pressure, push and open the bypass discharge valve and the first discharge valve, and be discharged from the first compression chamber to the internal space of the closed casing through the bypass discharge port, the intermediate chamber, and the first discharge port. According to the fourth aspect, a volume control compressor of the so-called cylinder-selective type can be provided.

[0017] A fifth aspect provides the refrigeration cycle apparatus as set forth in any one of the first to fourth aspects, wherein the controller can control the flow path switching unit so as to connect the volume control path to the low-pressure introduction path at start-up of the refrigeration cycle apparatus, and can control the flow path switching unit so as to connect the volume control path to the high-pressure introduction path after elapse of a predetermined time from the start-up. Carrying out such control allows the liquid refrigerant to be quickly returned to the suction path even when the liquid refrigerant has been accumulated in the volume control path. As a result, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path can be prevented. That is, it is possible to prevent a situation where the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant after the start-up, and thus causes excessive increase in pressure in the volume control path.

[0018] A sixth aspect provides the refrigeration cycle apparatus as set forth in any one of the first to fifth aspects, wherein the controller can control the flow path switching unit so as to connect the volume control path to the low-pressure introduction path when operation of the refrigeration cycle apparatus is stopped. With this feature, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path can be prevented. That is, it is possible to prevent a situation where the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant after the start-up, and thus causes excessive increase in pressure in the volume control path.

[0019] A seventh aspect of the present disclosure provides a refrigeration cycle apparatus including:

a volume control compressor including a compression chamber, a bypass discharge port opening into the compression chamber, and a bypass discharge valve that opens and closes the bypass discharge port, the volume control compressor being capable of varying a suction volume by discharging a refrigerant, which is drawn into the compression chamber, from the compression chamber through the bypass discharge port while maintaining the refrigerant at a suction pressure;

a radiator that cools the refrigerant compressed by the compressor;

an expansion mechanism that expands the refrigerant cooled by the radiator;

an evaporator that heats the refrigerant expanded by the expansion mechanism;

a suction path that directs the refrigerant to be compressed from the evaporator to the compression chamber;

a discharge path that directs the compressed refrigerant from the compression chamber to the radiator;

a volume control path connected to the bypass discharge port;

a low-pressure introduction path connected to the suction path;

an on-off valve provided so as to make connection between the low-pressure introduction path and the volume control path;

a controller that controls the on-off valve so as to connect the volume control path to the low-pressure introduction path when a load on the refrigeration cycle apparatus is small, and that controls the on-off valve so as to disconnect the volume control path from the low-pressure introduction path when the load is large; and

a relief valve circuit having one end connected to the volume control path and another end connected to the discharge path.

[0020] According to the seventh aspect, the volume control path is connected to the low-pressure introduction path via the on-off valve. Therefore, it is possible to avoid a situation where the refrigerant containing a large amount of oil directly flows into the discharge path of the compressor through the bypass discharge port and the volume control path. Furthermore, since the relief valve circuit is provided, even when the liquid refrigerant accumulated temporarily in the volume control path expands due to increase in the temperature of the liquid refrigerant, and thus causes increase in pressure in the volume control path, the pressure can be diverted to the discharge path through the relief valve circuit.

[0021] An eighth aspect of the present disclosure provides a refrigeration cycle apparatus including:

a volume control compressor including: a first compression chamber; a second compression chamber; a closed casing having an internal space capable of retaining a refrigerant compressed in the first compression chamber and the refrigerant compressed in the second compression chamber; a bypass discharge port opening into the first compression chamber; a bypass discharge valve that opens and closes the bypass discharge port; an intermediate chamber that receives the refrigerant discharged from the first compression chamber through the bypass discharge port; a first discharge port that allows communication between the intermediate chamber and the internal space of the closed casing; and a first discharge valve that opens and closes the first discharge port;

a radiator that cools the refrigerant compressed by the compressor;

an expansion mechanism that expands the refrigerant cooled by the radiator;

an evaporator that heats the refrigerant expanded by the expansion mechanism;

a suction path that directs the refrigerant to be compressed from the evaporator to the first compression chamber and the second compression chamber;

a discharge path that directs the compressed refrigerant from the first compression chamber and the second compression chamber to the radiator;

a volume control path connected to the bypass discharge port via the intermediate chamber;

a low-pressure introduction path connected to the suction path;

an on-off valve provided so as to make connection between the low-pressure introduction path and the volume control path; and

a controller that controls the on-off valve in such a manner that:

(i) when a load on the refrigeration cycle apparatus is small, the volume control path is connected to the low-pressure introduction path so that the refrigerant drawn into the first compression chamber is discharged from the first compression chamber through the bypass discharge port while maintaining a suction pressure, and is returned to the suction path through the intermediate chamber, the volume control path, and the low-pressure introduction path; and

(ii) when the load is large, the volume control path is disconnected from the low-pressure introduction path so that the refrigerant drawn into the first compression chamber is compressed in the first compression chamber to a pressure higher than a discharge pressure of the compressor, pushes and opens the bypass discharge valve and the first discharge valve, and is discharged from the first compression chamber to the internal space of the closed casing through the bypass discharge port, the intermediate chamber, and the first discharge port.

[0022] According to the eighth aspect, the volume control path is connected to the low-pressure introduction path via the on-off valve. Therefore, it is possible to avoid a situation where the refrigerant containing a large amount of oil directly flows into the discharge path of the compressor through the bypass discharge port and the volume control path. Furthermore, according to the eighth aspect, formation of a closed space in the refrigeration circuit can be avoided. Therefore, the pressure in the volume control path cannot be increased excessively even when the liquid refrigerant fills the volume control path, and then expands due to increase in the temperature of the liquid refrigerant. This is because when the pressure in the volume control path is increased, the first discharge valve is opened, and thus the pressure can be diverted to the internal space of the closed casing.

[0023] A ninth aspect provides the refrigeration cycle apparatus as set forth in the seventh or eighth aspect, wherein the controller controls the on-off valve so as to connect the volume control path to the low-pressure introduction path at start-up of the refrigeration cycle apparatus, and controls the on-off valve so as to disconnect the volume control path from the low-pressure introduction path after elapse of a predetermined time from the start-up. According to the ninth aspect, the same effect as in the sixth aspect can be obtained.

[0024] A tenth aspect provides the refrigeration cycle apparatus as set forth in any one of the seventh to ninth aspects, wherein the controller controls the on-off valve so as to connect the volume control path to the low-pressure introduction path when operation of the refrigeration cycle apparatus is stopped. With this feature, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path can be prevented. That is, it is possible to prevent a situation where the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant after the start-up, and thus causes excessive increase in pressure in the volume control path.

[0025] Hereinafter, embodiments of the present invention will be described with reference to the drawings. The present invention is not limited by the embodiments described below.

(Embodiment 1)

[0026] As shown in FIG. 1, a refrigeration cycle apparatus 100 of the present embodiment includes a volume control compressor 101, a first four-way valve 102, a first heat exchanger 103, an expansion mechanism 104, a second heat exchanger 105, and an accumulator 106. These components are connected to each other by flow paths 10a to 10f so as to form a refrigeration circuit. The flow paths 10a to 10f are respectively constituted by refrigerant pipes.

[0027] The first heat exchanger 103 is a radiator that cools a refrigerant compressed by the compressor 101 or an evaporator that heats the refrigerant expanded by the expansion mechanism 104. When the first heat exchanger 103 functions as a radiator, the second heat exchanger 105 functions as an evaporator. When the first heat exchanger 103 functions as an evaporator, the second heat exchanger 105 functions as a radiator. The expansion mechanism 104 has the function of expanding the refrigerant cooled by the radiator, and is typically constituted by an expansion valve. The expansion mechanism 104 may be constituted by a positive-displacement expander capable of recovering the expansion energy of the refrigerant.

[0028] The compressor 101 is a hermetic compressor, and includes a closed casing 1, a motor 2, and a compression mechanism 3. The motor 2 and the compression mechanism 3 are disposed in the closed casing 1. The closed casing 1 has an internal space 28 capable of retaining the refrigerant compressed by the compression mechanism 3. That is, the compressor 101 is a compressor of the so-called high-pressure shell type. The compression mechanism 3 is connected to the motor 2 by a shaft 4. The compression mechanism 3 is a positive-displacement fluid mechanism, and is driven by the motor 2 so as to compress the refrigerant.

[0029] As shown in FIG. 2, the compression mechanism 3 includes a suction port 27, a discharge port 29, a compression chamber 25, a bypass discharge port 16 opening into the compression chamber 25, and a bypass discharge valve 35 that opens and closes the bypass discharge port 16. When the compressor 101 is operated in a high volume mode, all of the refrigerant drawn into the compression chamber 25 through the suction port 27 is compressed in the compression chamber 25, and is discharged to the internal space 28 of the closed casing 1 through the discharge port 29. On the other hand, when the compressor 101 is operated in a low volume mode, a part of the refrigerant drawn into the compression chamber 25 through the suction port 27 pushes and opens the bypass discharge valve 35, and is discharged from the compression chamber 25 through the bypass discharge port 16. The suction volume of the compressor 101 is varied by switching between the high volume mode and the low volume mode.

[0030] Specifically, when the compressor 101 is operated in the low volume mode, a part of the refrigerant drawn into the compression chamber 25 through the suction port 27 is discharged from the compression chamber 25 through the bypass discharge port 16 while maintaining the suction pressure (without being substantially compressed). The remaining part of the refrigerant drawn into the compression chamber 25 through the suction port 27 is compressed in the compression chamber 25, and is discharged from the compression chamber 25 through the discharge port 29. As described later, the refrigerant discharged from the compression chamber 25 through the bypass discharge port 16 is returned to the flow path 10e serving as a suction path. Therefore, unnecessary compression work is not performed by the compressor 101.

[0031] The bypass discharge valve 35 is constituted by a reed valve including a reed 36 and a valve seat 37. The reed 36 and the valve seat 37 are fixed to a cylinder 5 by a fixing component 38 such as a screw and a bolt. The bypass discharge valve 35 is opened and closed depending on the pressure difference between the front and back surfaces of the reed 36. Any of the several discharge valves described in the present specification can be constituted by a reed valve.

[0032] In addition, the compression mechanism 3 includes the cylinder 5, a piston 8, a vane 9, and a spring 10. An upper bearing and a lower bearing (which are not shown) are respectively disposed on and under the cylinder 5 so as to close the cylinder 5. The piston 8 fitted to an eccentric portion 4a of the shaft 4 is disposed inside the cylinder 5 so as to form the compression chamber 25 inside the cylinder 5. A vane groove 24 is formed in the cylinder 5. The vane 9 having one end contacting the outer circumferential surface of the piston 8 is placed in the vane groove 24. The spring 10 is disposed in the vane groove 24 so as to push the vane 9 toward the piston 8. The compression chamber 25 between the cylinder 5 and the piston 8 is divided by the vane 9, and thus a suction chamber 25a and a compression-discharge chamber 25b are formed. The refrigerant to be compressed is introduced to the compression chamber 25 (suction chamber 25a) through the flow path 10f and the suction port 27. The refrigerant having been compressed is introduced to the internal space 28 of the closed casing 1 from the compression chamber 25 (compression-discharge chamber 25b) through the discharge port 29. A discharge valve, which is not shown, is provided on the discharge port 29. The vane 9 may be integrated with the piston 8. That is, the piston 8 and the vane 9 may be constituted by a so-called swing piston.

[0033] In the present embodiment, the position of the bypass discharge port 16 is set so that the suction volume in the low volume mode is 1/2 of the suction volume in the high volume mode. However, the position of the bypass discharge port 16 is not limited, and may be set according to the suction volume required in the low volume mode. In addition, two or more bypass discharge ports 16 may be provided. In this case, the compressor 101 can be operated at a suction volume selected from a plurality of suction volumes.

[0034] In the present embodiment, the compressor 101 is a rotary compressor. However, the type of the compressor 101 is not particularly limited as long as the suction volume can be varied. Another type of compressor, such as a reciprocating compressor and a scroll compressor described in Patent Literature 1 (JP 2008-240699 A), can be used.

[0035] As shown in FIG. 1, the flow path 10a forms a discharge path that directs the refrigerant compressed by the compressor 101 from the compression chamber 25 to the radiator (the first heat exchanger 103 or the second heat exchanger 105). The flow path 10e, the accumulator 106, and the flow path 10f form a suction path that directs the refrigerant to be compressed from the evaporator (the first heat exchanger 103 or the second heat exchanger 105) to the compression chamber 25.

[0036] The refrigeration cycle apparatus 100 further includes a volume control path 111, a second four-way valve 112, a high-pressure introduction path 114, a low-pressure introduction path 116, a check valve 120, and a controller 117.

[0037] The volume control path 111 is connected to the bypass discharge port 16 of the compressor 101. The second four-way valve 112 is a flow path switching unit that supplies either the discharge pressure of the compressor 101 or the suction pressure of the compressor 101 as a control pressure to the volume control path 111. The high-pressure introduction path 114 has one end connected to the second four-way valve 112 and the other end connected to the flow path 10a. The low-pressure introduction path 116 has one end connected to the second four-way valve 112 and the other end connected to the flow path 10e. The check valve 120 is provided on the high-pressure introduction path 114 so as to permit a flow of the refrigerant in a direction from the flow path 10a to the second four-way valve 112, and preclude a flow in the opposite direction. The paths 111, 114, and 116 can be respectively constituted by refrigerant pipes.

[0038] In the present embodiment, the second four-way valve 112 having one connection port closed is used as the flow path switching unit. However, the structure of the flow path switching unit is not limited as long as either the discharge pressure of the compressor 101 or the suction pressure of the compressor 101 can be supplied as a control pressure to the volume control path 111. The other end of the low-pressure introduction path 116 may be connected to the accumulator 106 or to the flow path 10f.

[0039] The controller 117 controls the second four-way valve 112 so that the suction volume of the compressor 101 is increased or decreased in accordance with the load on the refrigeration cycle apparatus 100. Specifically, when the load is small, the controller 117 controls the second four-way valve 112 so as to connect the volume control path 111 to the low-pressure introduction path 116, and when the load is large, the controller 117 controls the second four-way valve 112 so as to connect the volume control path 111 to the high-pressure introduction path 114. The controller 117 can be constituted by a DSP (Digital Signal Processor) including an A/D conversion circuit, an input/output circuit, an arithmetic circuit, a storage device, etc. The controller 117 may include a drive circuit that controls the motor 2 of the compressor 101.

[0040] Next, the operation of the refrigeration cycle apparatus 100 will be described.

[0041] When the motor 2 of the compressor 101 is activated, the compressor 101 draws a low-pressure gas refrigerant thorough the flow path 10f (suction path), and compresses the refrigerant. The high-pressure gas refrigerant is discharged to the internal space 28 of the closed casing 1, and is introduced to the first heat exchanger 103 (radiator) through the internal space 28 of the closed casing 1, the flow path 10a, the first four-way valve 102, and the flow path 10b. In the first heat exchanger 103, the refrigerant is cooled and condensed. The high-pressure liquid refrigerant is introduced to the expansion mechanism 104 from the first heat exchanger 103, and is reduced in pressure by the function of the expansion mechanism 104. The gas-liquid two-phase refrigerant is introduced to the second heat exchanger 105 (evaporator) from the expansion mechanism 104, and is heated and evaporated in the second heat exchanger 105. The gas refrigerant is drawn into the compressor 101 again through the accumulator 106.

[0042] The compressor 101 is configured to vary the suction volume using the discharge pressure and the suction pressure. When the second four-way valve 112 is kept in the state shown in FIG. 1, the discharge pressure of the compressor 101 is supplied to the volume control path 111. In this case, the bypass discharge valve 35 is closed, and thus the compressor 101 is operated at a relatively large suction volume (high volume mode).

[0043] When the load on the refrigeration cycle apparatus 100 is decreased, the rotational speed of the motor 2 of the compressor 101 is reduced by an inverter. Consequently, the power of the refrigeration cycle apparatus 100 is decreased, and efficient operation is performed. However, when the load is further decreased, the rotational speed of the motor 2 reaches the lower limit value, and further follow-up control of the power becomes difficult.

[0044] When the operation needs to be performed with a lower power, the controller 117 switches the state of the second four-way valve 112 from the state shown in FIG. 1 to the state shown in FIG. 3. Accordingly, the volume control path 111 is disconnected from the high-pressure introduction path 114, and is connected to the low-pressure introduction path 116. As a result, the suction pressure of the compressor 101 is supplied to the volume control path 111. The suction pressure of the compressor 101 acts on the bypass discharge valve 35. In this case, when the volume of the compression chamber 25 is reduced, the refrigerant in the compression chamber 25 is pushed away by the piston 8, and the bypass discharge valve 35 is accordingly opened. During the period in which the bypass discharge valve 35 is open, and the bypass discharge port 16 and the compression chamber 25 communicate with each other, the refrigerant drawn into the compression chamber 25 is returned to the flow path 10e through the volume control path 111, the second four-way valve 112, and the low-pressure introduction path 116. That is, the compressor 101 is operated at a relatively small suction volume (low volume mode).

[0045] Assuming that the rotational speed of the compressor 101 is constant, the amount of the refrigerant discharged from the compressor 101 in the low volume mode is smaller than the amount of the refrigerant discharged in the high volume mode. Therefore, switching of the operation mode between the high volume mode and the low volume mode can widen the range within which follow-up control of the power is possible, and particularly can lower the lower limit value.

[0046] In the present embodiment, the high-pressure introduction path 114 is provided with the check valve 120. In the high volume mode shown in FIG. 1, even when the internal pressure of the compression chamber 25 exceeds the discharge pressure, and the high-pressure refrigerant is discharged from the compression chamber 25 through the bypass discharge port 16, the high-pressure refrigerant is blocked by the check valve 120. The check valve 120 does not permit a flow from the volume control path 111 to the flow path 10a, and obstructs the high-pressure introduction path 114. Therefore, it is possible to prevent a situation where the refrigerant containing a large amount of oil is discharged from the compressor 101, and the large amount of oil circulates in the refrigeration circuit. As a result, heat transfer in the heat exchangers 103 and 105 is improved, and the pressure loss which occurs when the refrigerant passes through the flow paths 10a to 10f is reduced, so that the coefficient of performance (COP) of the refrigeration cycle is increased. The volume control path 111, the second four-way valve 112, and a portion of the high-pressure introduction path 114, are filled with the refrigerant compressed in the compression chamber 25 to the maximum pressure. Accordingly, the bypass discharge valve 35 can also be kept closed.

[0047] In addition, at the start-up of the refrigeration cycle apparatus 100, the controller 117 controls the second four-way valve 112 so as to connect the volume control path 111 to the low-pressure introduction path 116. Then, after elapse of a predetermined time (e.g., 1 to 5 minutes), the controller 117 controls the second four-way valve 112 so as to connect the volume control path 111 to the high-pressure introduction path 114. Specifically, when the predetermined time has elapsed after activation of the motor 2, it is determined whether the operation should be performed in the low volume mode or in the high volume mode, based on the magnitude of the power required for the refrigeration cycle apparatus 100. When the operation should be performed in the high volume mode, the volume control path 111 is connected to the high-pressure introduction path 114. When the operation should be performed in the low volume mode, the connection between the volume control path 111 and the low-pressure introduction path 116 is maintained. That is, at the start-up, preliminary operation is performed in the low volume mode.

[0048] When the ambient temperature is low, such as in winter, there is a possibility that the liquid refrigerant is accumulated in the volume control path 111. Even when the liquid refrigerant is accumulated in the volume control path 111, performing the above preliminary operation allows the liquid refrigerant to be quickly returned to the flow path 10e. As a result, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path 111 can be prevented. That is, it is possible to prevent a situation where the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant after the start-up, and thus causes excessive increase in pressure in the volume control path 111. In addition, in view of the preliminary operation, the low-pressure introduction path 116 is preferably connected to the flow path 10e or the accumulator 106. In this case, supply of the liquid refrigerant to the compressor 101 at the start-up can be prevented.

[0049] The preliminary operation is performed at the start-up of the refrigeration cycle apparatus 100. The "start-up of the refrigeration cycle apparatus 100" may encompass restart after a temporary stop. In addition, the preliminary operation can be applied also to other embodiments and modifications described in the present specification.

[0050] In addition, when the operation of the refrigeration cycle apparatus 100 is stopped, the controller 117 may control the second four-way valve 112 so as to connect the volume control path 111 to the low-pressure introduction path 116. Specifically, the operation of the refrigeration cycle apparatus 100 is desirably stopped in a state where the volume control path 111 is connected to the low-pressure introduction path 116. In this case, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path 111 can be prevented. That is, it is possible to prevent a situation where the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant after the start-up, and thus causes excessive increase in pressure in the volume control path 111.

(Modification 1)

[0051] As shown in FIG. 4, a refrigeration cycle apparatus 200 according to a modification 1 is different from the refrigeration cycle apparatus 100 of the embodiment 1 in that the refrigeration cycle apparatus 200 further includes a relief valve circuit 221. Hereinafter, common components between the embodiments or modifications described earlier and the embodiments or modifications described later are denoted by the same reference characters, and the description thereof is omitted.

[0052] The high-pressure introduction path 114 has a first portion 114a between the check valve 120 and the second four-way valve 112 (flow path switching unit), and a second portion 114b between the check valve 120 and the flow path 10a (discharge path). The relief valve circuit 221 has one end connected to the first portion 114a, and has the other end connected to the second portion 114b or the flow path 10a so that the check valve 120 is bypassed. When the difference between the pressure in the first portion 114a and the pressure in the second portion 114b exceeds a certain value, the relief valve circuit 221 allows the refrigerant to flow out of the first portion 114a into the flow path 10a (or the second portion 114b), and thus reduces the pressure in the first portion 114a.

[0053] With the refrigeration cycle apparatus 200, the same effect as provided by the preliminary operation described in the embodiment 1 is obtained. That is, generation of abnormal pressure caused by confinement of the liquid refrigerant in the volume control path 111 or the like can be prevented. When the ambient temperature is low, such as in winter, there is a possibility that the liquid refrigerant is accumulated in the volume control path 111, the four-way valve 112, and the first portion 114a of the high-pressure introduction path 114. It is predicted that the phenomenon of accumulation of the liquid refrigerant in the volume control path 111 or the like occurs when the path from the bypass discharge valve 35 to the check valve 120 is cooled. There is also a possibility that the liquid refrigerant is accumulated in the volume control path 111 or the like while the compressor 101 is not in operation. In the presence of the liquid refrigerant accumulated in a closed space such as the volume control path 111, there is a possibility that the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant, and thus causes excessive increase in pressure in the closed space such as the volume control path 111. With the relief valve circuit 221, excessive increase in pressure in the volume control path 111, the four-way valve 112, and the first portion 114a of the high-pressure introduction path 114, can be prevented by diverting the pressure to the flow path 10a.

(Modification 2)

[0054] As shown in FIG. 5, a refrigeration cycle apparatus 300 according to a modification 2 is different from the embodiment 1 in that the refrigeration cycle apparatus 300 includes a compressor 301 having a structure different from that of the compressor 101 of the embodiment 1.

[0055] As shown in FIG. 6, the compressor 301 includes the closed casing 1, the motor 2, and a compression mechanism 30, and is configured as a multicylinder rotary compressor (two-cylinder compressor in the case of the present modification). The refrigerant compressed by the compression mechanism 30 is introduced to the flow path 10a thorough the internal space 28 of the closed casing 1. The compression mechanism 30 has a first compression chamber 40, a second compression chamber 42, an intermediate chamber 69, a first discharge port 67, a first discharge valve 63, a second discharge port 71, a second discharge valve 73, a bypass discharge port 65, and a bypass discharge valve 61.

[0056] The flow path 10a forms a discharge path that directs the refrigerant compressed by the compressor 301 from the first compression chamber 40 and the second compression chamber 42 to the radiator (the first heat exchanger 103 or the second heat exchanger 105). The flow path 10e, the accumulator 106, and the flow path 10f, form a suction path that directs the refrigerant to be compressed from the evaporator (the first heat exchanger 103 or the second heat exchanger 105) to the first compression chamber 40 and the second compression chamber 42.

[0057] The bypass discharge port 65 opens into the first compression chamber 40. The bypass discharge valve 61 is provided so as to open and close the bypass discharge port 65. The intermediate chamber 69 is a space that receives the refrigerant discharged from the first compression chamber 40 through the bypass discharge port 65. The intermediate chamber 69 and the internal space 28 of the closed casing 1 can communicate with each other via the first discharge port 67. The first discharge valve 63 is provided so as to open and close the first discharge port 67. The volume control path 111 is connected to the bypass discharge port 65 via the intermediate chamber 69. Thus, in the compressor 301, two discharge valves 61 and 63 are provided on the path from the first compression chamber 40 to the internal space 28 of the closed casing 1. The volume control path 111 is connected to the space (intermediate chamber 69) between the discharge valve 61 and the discharge valve 63.

[0058] In addition, the compression mechanism 30 has a first cylinder 41, an intermediate plate 71, a second cylinder 43, a first piston 51, a second piston 53, an upper bearing 46, a lower bearing 48, a muffler 77, and a muffler 75. The first piston 51 is fitted to a first eccentric portion 4a of the shaft 4 inside the first cylinder 41. The first compression chamber 40 is formed between the outer circumferential surface of the first piston 51 and the inner circumferential surface of the first cylinder 41. The second cylinder 43 is disposed concentrically with the first cylinder 41. The second piston 53 is fitted to a second eccentric portion 4b of the shaft 4 inside the second cylinder 43. The second compression chamber 42 is formed between the outer circumferential surface of the second piston 53 and the inner circumferential surface of the second cylinder 43.

[0059] The upper bearing 46 and the lower bearing 48 are respectively disposed on the first cylinder 41 and under the second cylinder 43. The intermediate plate 71 is disposed between the first cylinder 41 and the second cylinder 43. The first cylinder 41 is closed by the upper bearing 46 and the intermediate plate 71, and the second cylinder 43 is closed by the intermediate plate 71 and the lower bearing 48. The bypass discharge port 65, the intermediate chamber 69, and the first discharge port 67 form a path extending through the upper bearing 46 along the axial direction of the shaft 4. The muffler 77 is disposed on the upper bearing 46. In the high volume mode, the refrigerant compressed in the first compression chamber 40 is introduced to the internal space 28 of the closed casing 1 through the bypass discharge port 65, the intermediate chamber 69, the first discharge port 67, and the internal space of the muffler 77. The second discharge port 71 is formed in the lower bearing 48 in such a manner that a path extending thorough the lower bearing 48 along the axial direction of the shaft 4 is formed. The muffler 75 is disposed under the lower bearing 48. The internal space of the muffler 75 communicates with the internal space of the muffler 77 via a vertical path which is not shown. The refrigerant compressed in the second compression chamber 42 is introduced to the internal space 28 of the closed casing 1 through the second discharge port 71, the internal space of the muffler 75, the vertical path, and the internal space of the muffler 77.

[0060] The first compression chamber 40 and the second compression chamber 42 function as compression chambers that are independent from each other. In the high volume mode, the refrigerant is compressed in each of the first compression chamber 40 and the second compression chamber 42. In the low volume mode, the refrigerant is compressed in the second compression chamber 42, but is not compressed in the first compression chamber 40. In the low volume mode, since the suction pressure is supplied to the intermediate chamber 69, the refrigerant drawn into the first compression chamber 40 pushes and opens the bypass discharge valve 61 without being compressed, and is introduced to the volume control path 111 through the bypass discharge port 65 and the intermediate chamber 69. Thus, the compressor 301 is configured as a volume control compressor of the so-called cylinder-selective type.

[0061] Next, the operation of the refrigeration cycle apparatus 300 will be described.

[0062] When the motor 2 is activated, the compressor 301 draws a low-pressure gas refrigerant through the flow path 10f (suction path), and compresses the refrigerant. The high-pressure gas refrigerant is discharged to the internal space 28 of the closed casing 1. Specifically, the refrigerant compressed in the first compression chamber 40 is discharged to the internal space 28 of the closed casing 1 through the bypass discharge port 65, the intermediate chamber 69, the first discharge port 67, and the muffler 77. The refrigerant compressed in the second compression chamber 42 is discharged to the internal space 28 of the closed casing 1 through the second discharge port 71 and the muffler 75. In the internal space 28, the refrigerant compressed in the first compression chamber 40 merges with the refrigerant compressed in the second compression chamber 42. The subsequent refrigerant flow is as described in the embodiment 1.

[0063] When the second four-way valve 112 is kept in the state shown in FIG. 5, the discharge pressure of the compressor 301 is supplied to the volume control path 111 and the intermediate chamber 69. In this case, the refrigerant drawn into the first compression chamber 40 is compressed in the first compression chamber 40 to a pressure higher than the discharge pressure, pushes and opens the bypass discharge valve 61 and the first discharge valve 63, and is discharged from the first compression chamber 40 to the internal space 28 of the closed casing 1 through the bypass discharge port 65, the intermediate chamber 69, and the first discharge port 67. Since the work of compressing the refrigerant is performed in both the first compression chamber 40 and the second compression chamber 42, the compressor 301 is operated at a relatively large suction volume (high volume mode).

[0064] When the load on the refrigeration cycle apparatus 300 is decreased, the rotational speed of the motor 2 of the compressor 301 is reduced by an inverter. Consequently, the power of the refrigeration cycle apparatus 300 is decreased, and efficient operation is performed.

However, when the load is further decreased, the rotational speed of the motor 2 reaches the lower limit value, and further follow-up control of the power becomes difficult.

[0065] When the operation needs to be performed with a lower power, the controller 117 switches the state of the second four-way valve 112 from the state shown in FIG. 5 to the state shown in FIG. 3. Consequently, the volume control path 111 is disconnected from the high-pressure introduction path 114, and is connected to the low-pressure introduction path 116. The suction pressure of the compressor 301 is supplied to the volume control path 111 and the intermediate chamber 69. In this case, the compressor 301 is operated at a relatively small suction volume (low volume mode).

[0066] In the low volume mode, the bypass discharge valve 61 is constantly open since the pressure in the intermediate chamber 69 is equal to the suction pressure. Therefore, the refrigerant drawn into the first compression chamber 40 is discharged from the first compression chamber 40 to the intermediate chamber 69 through the bypass discharge port 65 while maintaining the suction pressure (without being substantially compressed). A high pressure of the internal space 28 of the closed casing 1 is applied to one surface of the first discharge valve 63, and therefore, the first discharge valve 63 is not opened. As a result, the refrigerant discharged to the intermediate chamber 69 is returned to the flow path 10e (suction path) through the volume control path 111, the second four-way valve 112, and the low-pressure introduction path 116.

[0067] In the high volume mode, the volume control path 111 is connected to the high-pressure introduction path 114 as shown in FIG. 5. Consequently, the pressure in the intermediate chamber 69 is made equal to the discharge pressure. However, due to the influence of inevitable pressure loss, the pressure in the flow path 10a is slightly lower than the pressure in the internal space 28 of the closed casing 1. In the case where the pressure in the intermediate chamber 69 is lower than the pressure in the internal space 28 of the closed casing 1, the first discharge valve 63 is not opened. The refrigerant discharged to the intermediate chamber 69 fills the volume control path 111, the second four-way valve 112, and a portion of the high-pressure introduction pipe 114, and is blocked by the check valve 120. Since the check valve 120 does not permit a flow from the volume control path 111 to the flow path 10a, the pressures in the volume control path 111 and the intermediate chamber 69 gradually increase, and exceed the pressure in the internal space 28 of the closed casing 1. As a result, the first discharge valve 63 is opened. Thus, in the high volume mode, compression work is performed not only in the second compression chamber 42 but also in the first compression chamber 40. In addition, it is possible to prevent a situation where the refrigerant containing a large amount of oil is discharged from the compressor 301, and the large amount of oil circulates in the refrigeration circuit.

[0068] Furthermore, according to the present modification, any closed space is not formed in the refrigeration circuit. Therefore, the pressure in the volume control path 111 cannot be increased excessively even when the liquid refrigerant fills the volume control path 111, the second four-way valve 112, and a portion of the high-pressure introduction path 114, and then expands due to increase in the temperature of the liquid refrigerant. When the pressure in the volume control path 111 is increased, the first discharge valve 63 is opened, ant thus the pressure can be diverted to the internal space 28 of the closed casing 1.

[0069] According to the present modification, the first compression chamber 40 is located relatively near the motor 2. Therefore, the bypass path from the first compression chamber 40 to the volume control path 111 is shortened, and the pressure loss in the low volume mode can be reduced. However, the bypass discharge port 65 may be provided in the second compression chamber 42. That is, the compressor 301 may be configured to selectively disables the second compression chamber 42, instead of the first compression chamber 40.

(Embodiment 2)

[0070] As shown in FIG. 7, a refrigeration cycle apparatus 400 of the present embodiment is different from the refrigeration cycle apparatus 100 of the embodiment 1 in that the refrigeration cycle apparatus 400 includes the relief valve circuit 221 and an on-off valve 420 serving as means for switching the control pressure. The function and the effect of the relief valve circuit 221 are as described in the modification 1.

[0071] The on-off valve 420 is provided so as to make connection between the low-pressure introduction path 116 and the volume control path 111. An electromagnetic valve can be used as the on-off valve 420. The on-off valve 420 is closed in the high volume mode, and is opened in the low volume mode. That is, when the load on the refrigeration cycle apparatus 400 is small, the on-off valve 420 is controlled so as to connect the volume control path 111 to the low-pressure introduction path 116, and when the load is large, the on-off valve 420 is controlled so as to disconnect the volume control path 111 from the low-pressure introduction path 116.

[0072] According to the present embodiment, the volume control path 111 is connected to the low-pressure introduction path 116 via the on-off valve 420. Therefore, it is possible to avoid a situation where the refrigerant containing a large amount of oil directly flows into the discharge path of the compressor 101 through the bypass discharge port 16 and the volume control path 111.

[0073] Furthermore, also in the refrigeration cycle apparatus 400 of the present embodiment, there is a possibility that the liquid refrigerant is accumulated in the volume control path 111 for the reason described in the modification 2. However, even when the liquid refrigerant expands due to increase in the temperature of the liquid refrigerant, and thus causes increase in pressure in the volume control path 111, the pressure can be diverted to the discharge path (flow path 10a) through the relief valve circuit 221.

[0074] In the high volume mode, even when the internal pressure of the compression chamber 25 exceeds the discharge pressure, and the high-pressure refrigerant is discharged from the compression chamber 25 through the bypass discharge port 16, the high-pressure refrigerant is blocked by the on-off valve 420. Since the volume control path 111 is filled with the refrigerant compressed in the compression chamber 25 to the maximum pressure, the bypass discharge valve 35 can be kept closed. Therefore, it is possible to prevent a situation where the refrigerant containing a large amount of oil is discharged from the compressor 101, and the large amount of oil circulates in the refrigeration circuit.

(Modification 3)

[0075] As shown in FIG. 8, a refrigeration cycle apparatus 500 of a modification 3 is different from the refrigeration cycle apparatus 300 of the modification 2 in that the refrigeration cycle apparatus 500 includes the on-off valve 420 serving as means for switching the control pressure. That is, the refrigeration cycle apparatus 500 of the present modification corresponds to a refrigeration cycle apparatus of the embodiment 2 in which the compressor 101 is replaced by the compressor 301 of the modification 2 and from which the relief valve circuit 221 is omitted.

[0076] The on-off valve 420 is closed in the high volume mode, and is opened in the low volume mode. The function of the on-off valve 420 is as described in the embodiment 2. With the refrigeration cycle apparatus 500 of the present modification, both the advantage of the modification 2 and the advantage of the embodiment 2 can be obtained.

[0077] Also in the embodiment 2 and the modification 3, the preliminary operation as in the embodiment 1 may be performed. That is, the on-off valve 420 may be controlled so as to connect the volume control path 111 to the low-pressure introduction path 116 at the start-up of the refrigeration cycle apparatus 400 (or 500), and may then be controlled so as to disconnect the volume control path 111 from the low-pressure introduction path 116 after elapse of a predetermined time. That is, the on-off valve 420 is opened at the start-up. In addition, when the operation of the refrigeration cycle apparatus 400 (or 500) is stopped, the on-off valve 420 may be controlled so as to connect the volume control path 111 to the low-pressure introduction path 116. That is, the operation of the refrigeration cycle apparatus 400 (or 500) may be stopped in a state where the on-off valve 420 is open and where the volume control path 111 is connected to the low-pressure introduction path 116.

INDUSTRIAL APPLICABILITY

[0078] The refrigeration cycle apparatus of the present invention is useful for air conditioners, refrigerating machines, heaters, hot water dispensers, etc.

Claims

1. A refrigeration cycle apparatus comprising:

a volume control compressor comprising a compression chamber, a bypass discharge port opening into the compression chamber, and a bypass discharge valve that opens and closes the bypass discharge port, the volume control compressor being capable of varying a suction volume by discharging a refrigerant, which is drawn into the compression chamber, from the compression chamber through the bypass discharge port while maintaining the refrigerant at a suction pressure;

a radiator that cools the refrigerant compressed by the compressor;

an expansion mechanism that expands the refrigerant cooled by the radiator;

an evaporator that heats the refrigerant expanded by the expansion mechanism;

a suction path that directs the refrigerant to be compressed from the evaporator to the compression chamber;

a discharge path that directs the compressed refrigerant from the compression chamber to the radiator;

a volume control path connected to the bypass discharge port;

a flow path switching unit that supplies either a discharge pressure of the compressor or the suction pressure of the compressor as a control pressure to the volume control path;

a high-pressure introduction path having one end connected to the flow path switching unit and another end connected to the discharge path;

a low-pressure introduction path having one end connected to the flow path switching unit and another end connected to the suction path;

a controller that controls the flow path switching unit so as to connect the volume control path to the low-pressure introduction path when a load on the refrigeration cycle apparatus is small, and that controls the flow path switching unit so as to connect the volume control path to the high-pressure introduction path when the load is large; and

a check valve provided on the high-pressure introduction path, the check valve being configured to permit a flow of the refrigerant in a direction from the discharge path to the flow path switching unit and preclude a flow in an opposite direction.

2. The refrigeration cycle apparatus according to claim 1, wherein
the compressor further comprises a suction port and a discharge port, and
when the load is small, a part of the refrigerant drawn into the compression chamber through the suction port is discharged from the compression chamber through the bypass discharge port while maintaining the suction pressure, and a remaining part of the refrigerant drawn into the compression chamber through the suction port is compressed in the compression chamber, and is discharged from the compression chamber through the discharge port.

3. The refrigeration cycle apparatus according to claim 1, further comprising a relief valve circuit, wherein the high-pressure introduction path has a first portion between the check valve and the flow path switching unit, and a second portion between the check valve and the discharge path, and
the relief valve circuit has one end connected to the first portion and another end connected to the second portion or the discharge path.

4. The refrigeration cycle apparatus according to claim 1, wherein
the compressor is a hermetic multicylinder compressor further comprising: a first compression chamber as the compression chamber and a second compression chamber; a closed casing having an internal space capable of retaining the refrigerant compressed in the first compression chamber and the refrigerant compressed in the second compression chamber; an intermediate chamber that receives the refrigerant discharged from the first compression chamber through the bypass discharge port; a first discharge port that allows communication between the intermediate chamber and the internal space of the closed casing; and a first discharge valve that opens and closes the first discharge port,
the volume control path is connected to the bypass discharge port via the intermediate chamber,
when the load is small, the refrigerant drawn into the first compression chamber is discharged from the first compression chamber through the bypass discharge port while maintaining the suction pressure, and is returned to the suction path through the intermediate chamber, the volume control path, and the low-pressure introduction path, and
when the load is large, the refrigerant drawn into the first compression chamber is compressed in the first compression chamber to a pressure higher than the discharge pressure, pushes and opens the bypass discharge valve and the first discharge valve, and is discharged from the first compression chamber to the internal space of the closed casing through the bypass discharge port, the intermediate chamber, and the first discharge port.

5. The refrigeration cycle apparatus according to claim 1, wherein the controller controls the flow path switching unit so as to connect the volume control path to the low-pressure introduction path at start-up of the refrigeration cycle apparatus, and controls the flow path switching unit so as to connect the volume control path to the high-pressure introduction path after elapse of a predetermined time from the start-up.

6. The refrigeration cycle apparatus according to claim 1, wherein the controller controls the flow path switching unit so as to connect the volume control path to the low-pressure introduction path when operation of the refrigeration cycle apparatus is stopped.

7. A refrigeration cycle apparatus comprising:

a volume control compressor comprising a compression chamber, a bypass discharge port opening into the compression chamber, and a bypass discharge valve that opens and closes the bypass discharge port, the volume control compressor being capable of varying a suction volume by discharging a refrigerant, which is drawn into the compression chamber, from the compression chamber through the bypass discharge port while maintaining the refrigerant at a suction pressure;
a radiator that cools the refrigerant compressed by the compressor;
an expansion mechanism that expands the refrigerant cooled by the radiator;
an evaporator that heats the refrigerant expanded by the expansion mechanism;
a suction path that directs the refrigerant to be compressed from the evaporator to the compression chamber;
a discharge path that directs the compressed refrigerant from the compression chamber to the radiator;
a volume control path connected to the bypass discharge port;
a low-pressure introduction path connected to the suction path;
an on-off valve provided so as to make connection between the low-pressure introduction path and the volume control path;
a controller that controls the on-off valve so as to connect the volume control path to the low-pressure introduction path when a load on the refrigeration cycle apparatus is small, and that

controls the on-off valve so as to disconnect the volume control path from the low-pressure introduction path when the load is large; and
a relief valve circuit having one end connected to the volume control path and another end connected to the discharge path.

8. A refrigeration cycle apparatus comprising:

a volume control compressor comprising: a first compression chamber; a second compression chamber; a closed casing having an internal space capable of retaining a refrigerant compressed in the first compression chamber and the refrigerant compressed in the second compression chamber; a bypass discharge port opening into the first compression chamber; a bypass discharge valve that opens and closes the bypass discharge port; an intermediate chamber that receives the refrigerant discharged from the first compression chamber through the bypass discharge port; a first discharge port that allows communication between the intermediate chamber and the internal space of the closed casing; and a first discharge valve that opens and closes the first discharge port;
a radiator that cools the refrigerant compressed by the compressor;
an expansion mechanism that expands the refrigerant cooled by the radiator;
an evaporator that heats the refrigerant expanded by the expansion mechanism;
a suction path that directs the refrigerant to be compressed from the evaporator to the first compression chamber and the second compression chamber;
a discharge path that directs the compressed refrigerant from the first compression chamber and the second compression chamber to the radiator;
a volume control path connected to the bypass discharge port via the intermediate chamber;
a low-pressure introduction path connected to the suction path;
an on-off valve provided so as to make connection between the low-pressure introduction path and the volume control path; and
a controller that controls the on-off valve in such a manner that:

(i) when a load on the refrigeration cycle apparatus is small, the volume control path is connected to the low-pressure introduction path so that the refrigerant drawn into the first compression chamber is discharged from the first compression chamber through the bypass discharge port while maintaining a suction pressure, and is returned to the suction path through the intermediate chamber, the volume control path, and the low-pressure introduction path; and
(ii) when the load is large, the volume control path is disconnected from the low-pressure introduction path so that the refrigerant drawn into the first compression chamber is compressed in the first compression chamber to a pressure higher than a discharge pressure of the compressor, pushes and opens the bypass discharge valve and the first discharge valve, and is discharged from the first compression chamber to the internal space of the closed casing through the bypass discharge port, the intermediate chamber, and the first discharge port.

9. The refrigeration cycle apparatus according to claim 7, wherein the controller controls the on-off valve so as to connect the volume control path to the low-pressure introduction path at start-up of the refrigeration cycle apparatus, and controls the on-off valve so as to disconnect the volume control path from the low-pressure introduction path after elapse of a predetermined time from the start-up.

10. The refrigeration cycle apparatus according to claim 7, wherein the controller controls the on-off valve so as to connect the volume control path to the low-pressure introduction path when operation of the refrigeration cycle apparatus is stopped.

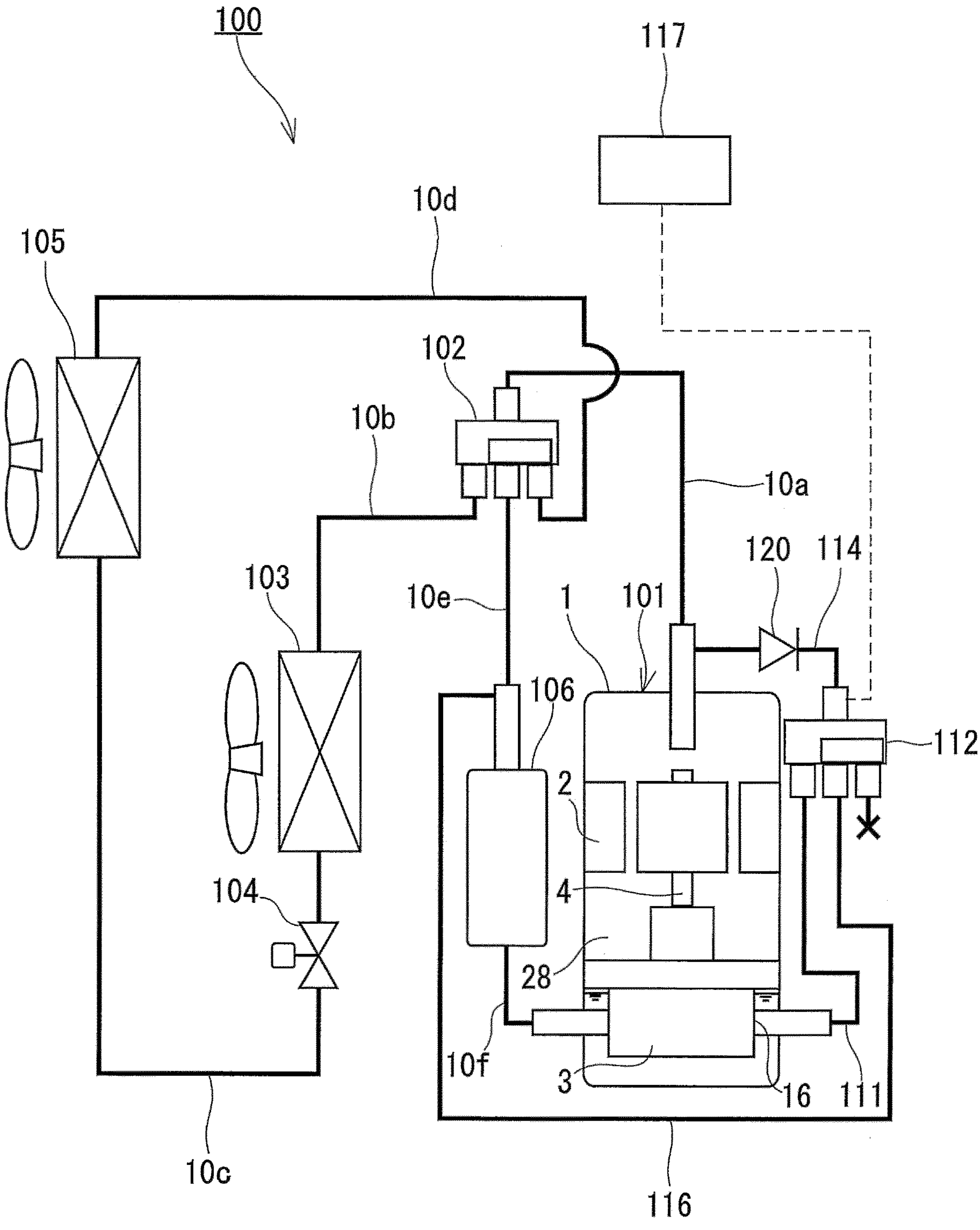

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FIG.1

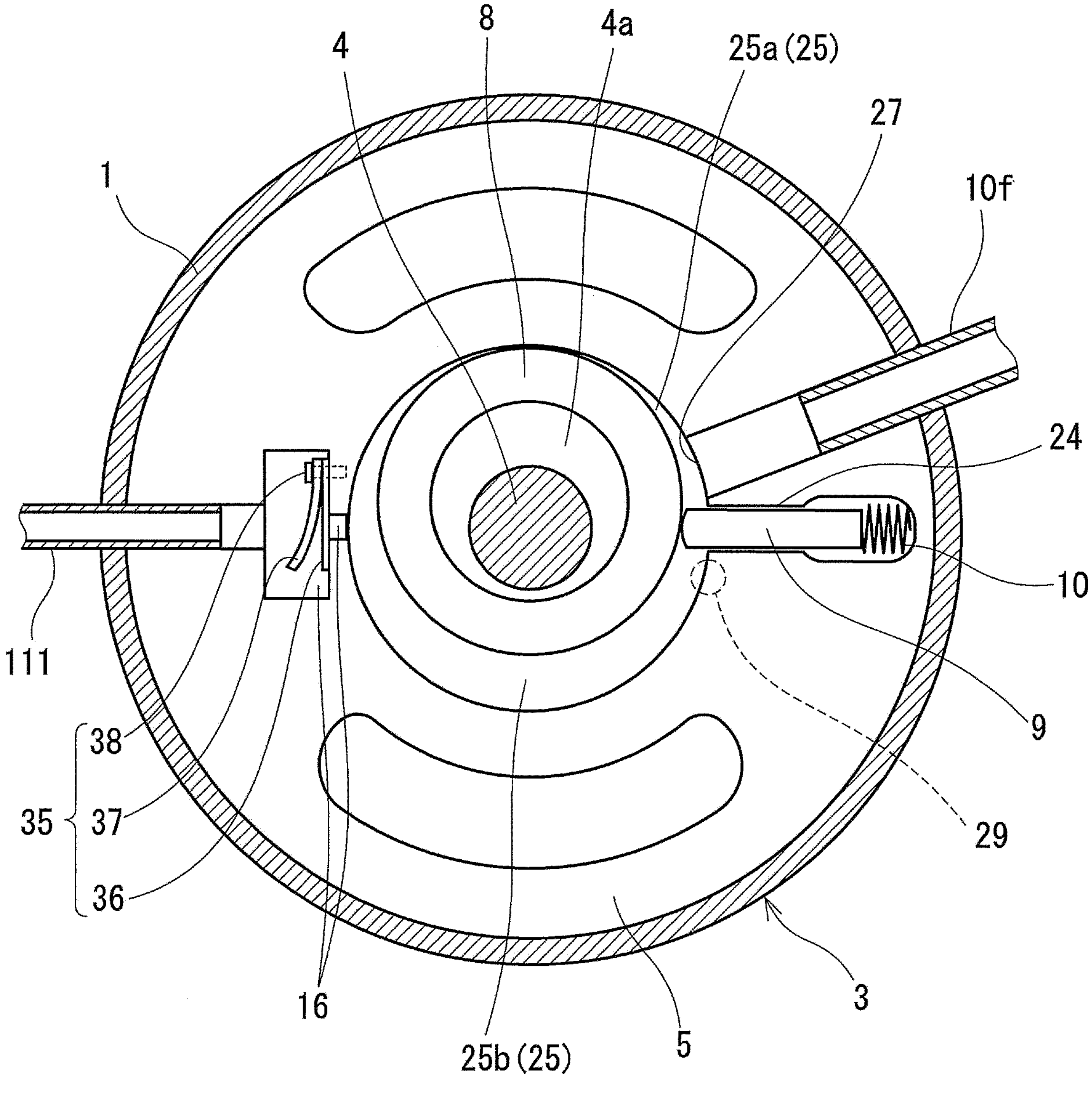

FIG.2

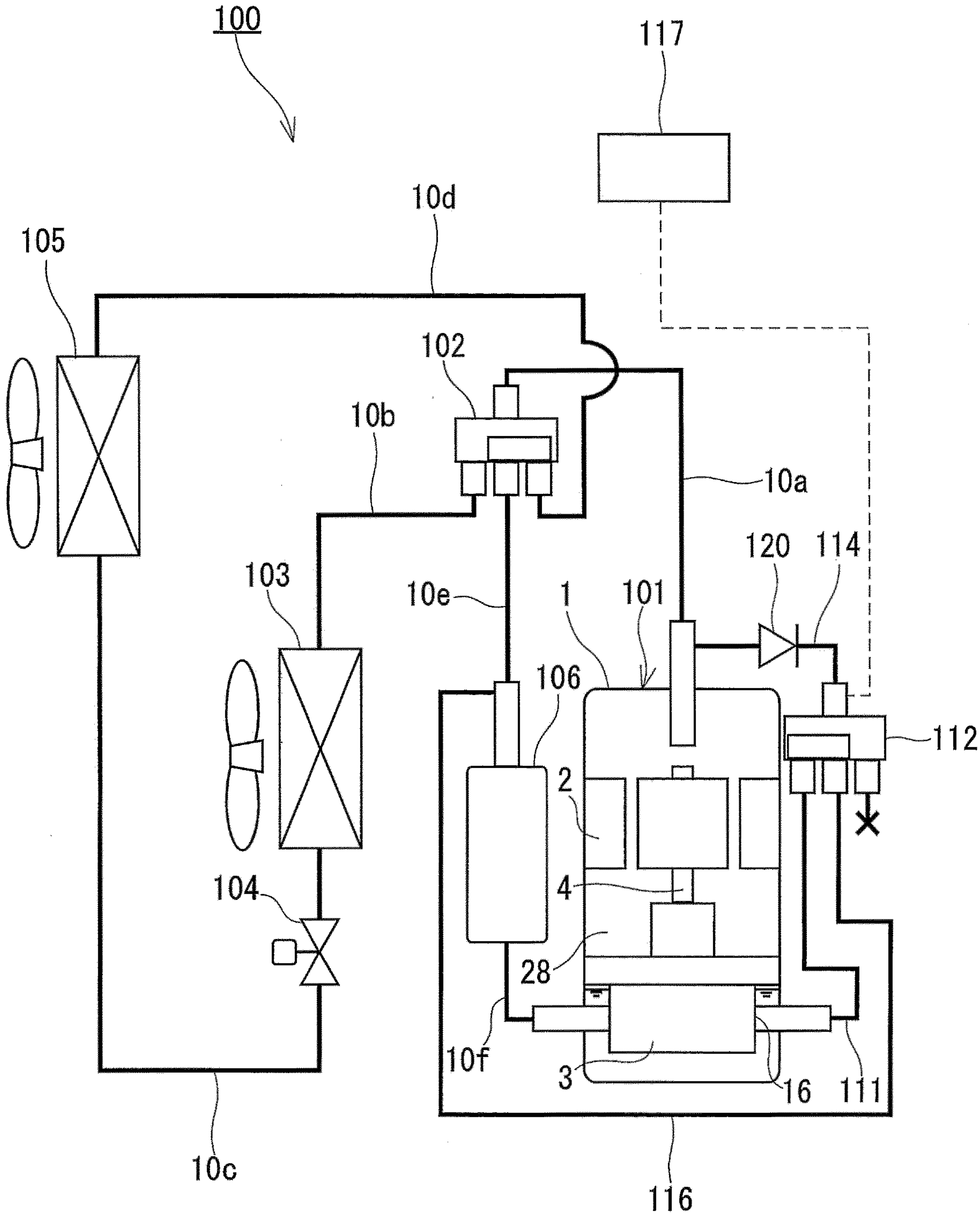
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FIG.3

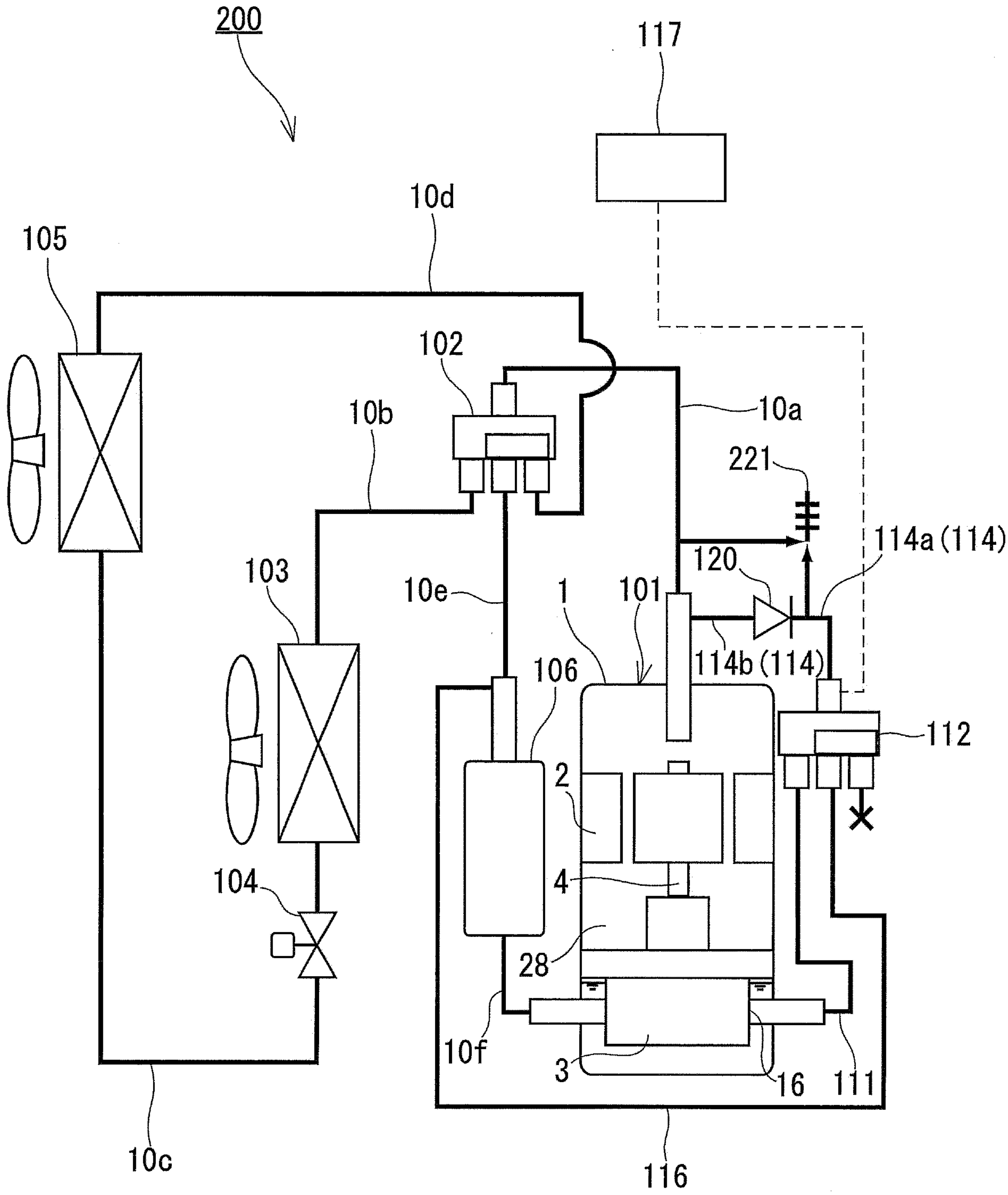
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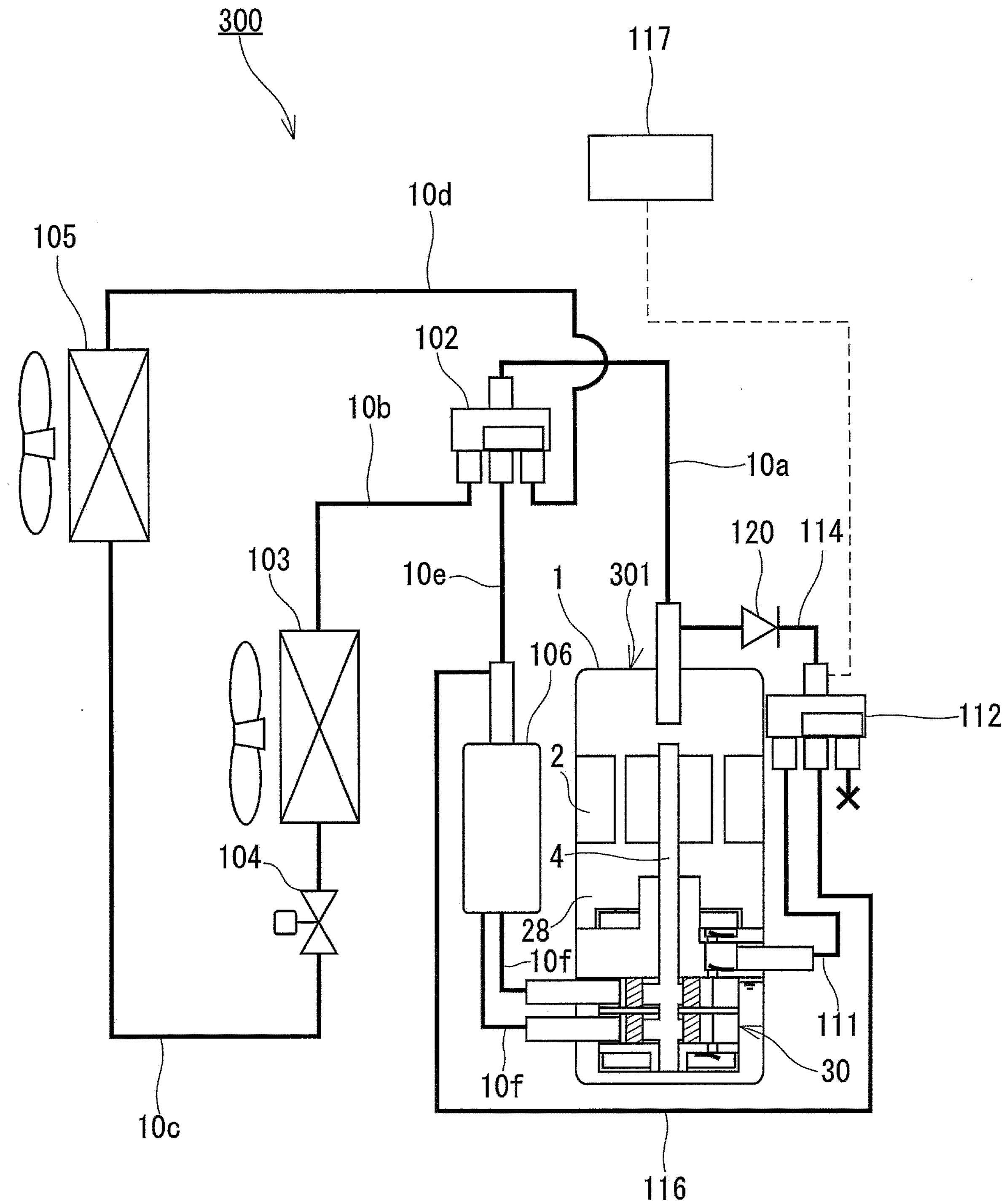
FIG.4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111
10f
30
10c
116

FIG.5

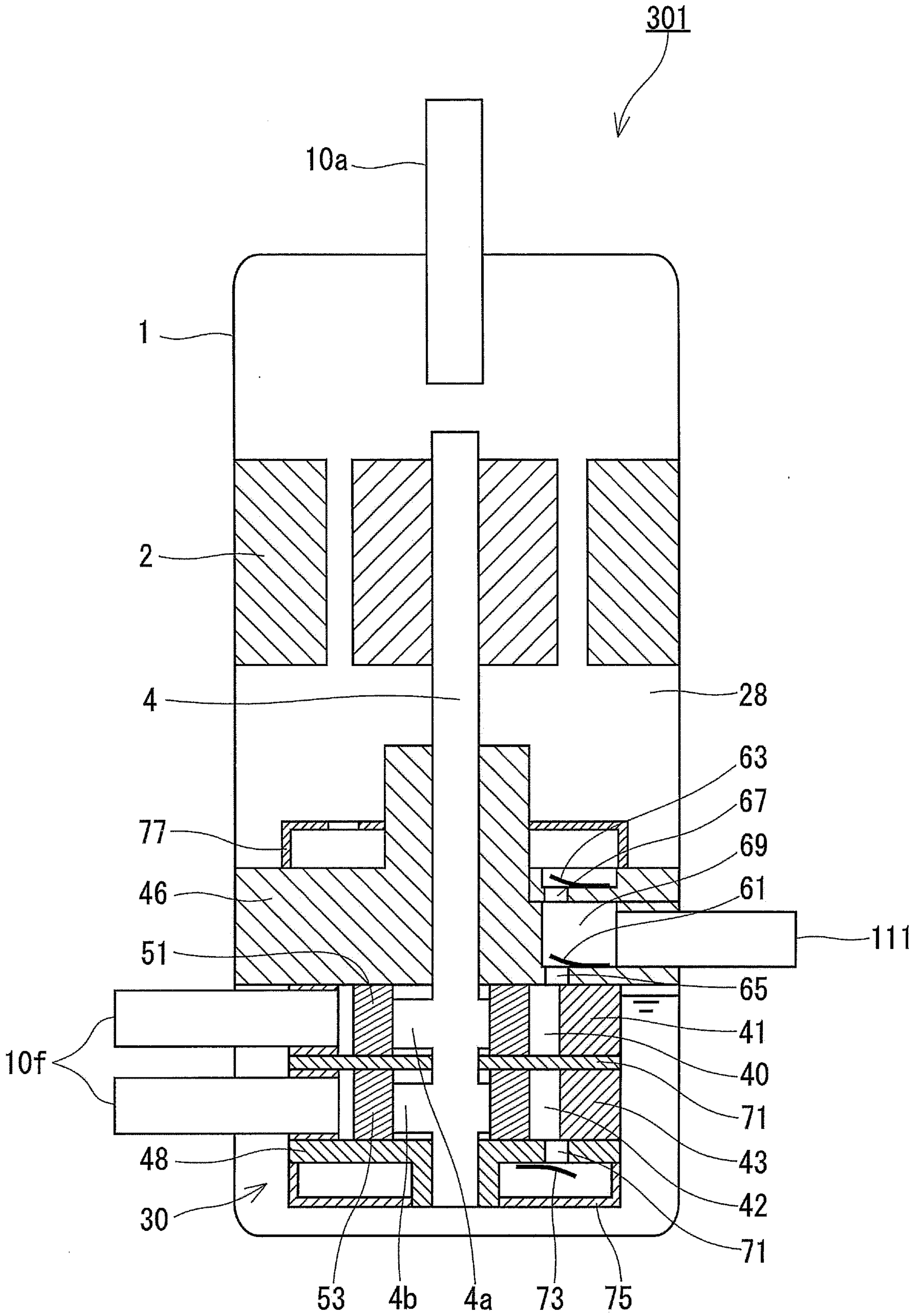
301
10a
1
2
4
28
63
67
69
61
77
46
111
51
65
41
40
10f
71
43
48
42
30
71
53
4b
4a
73
75

FIG.6

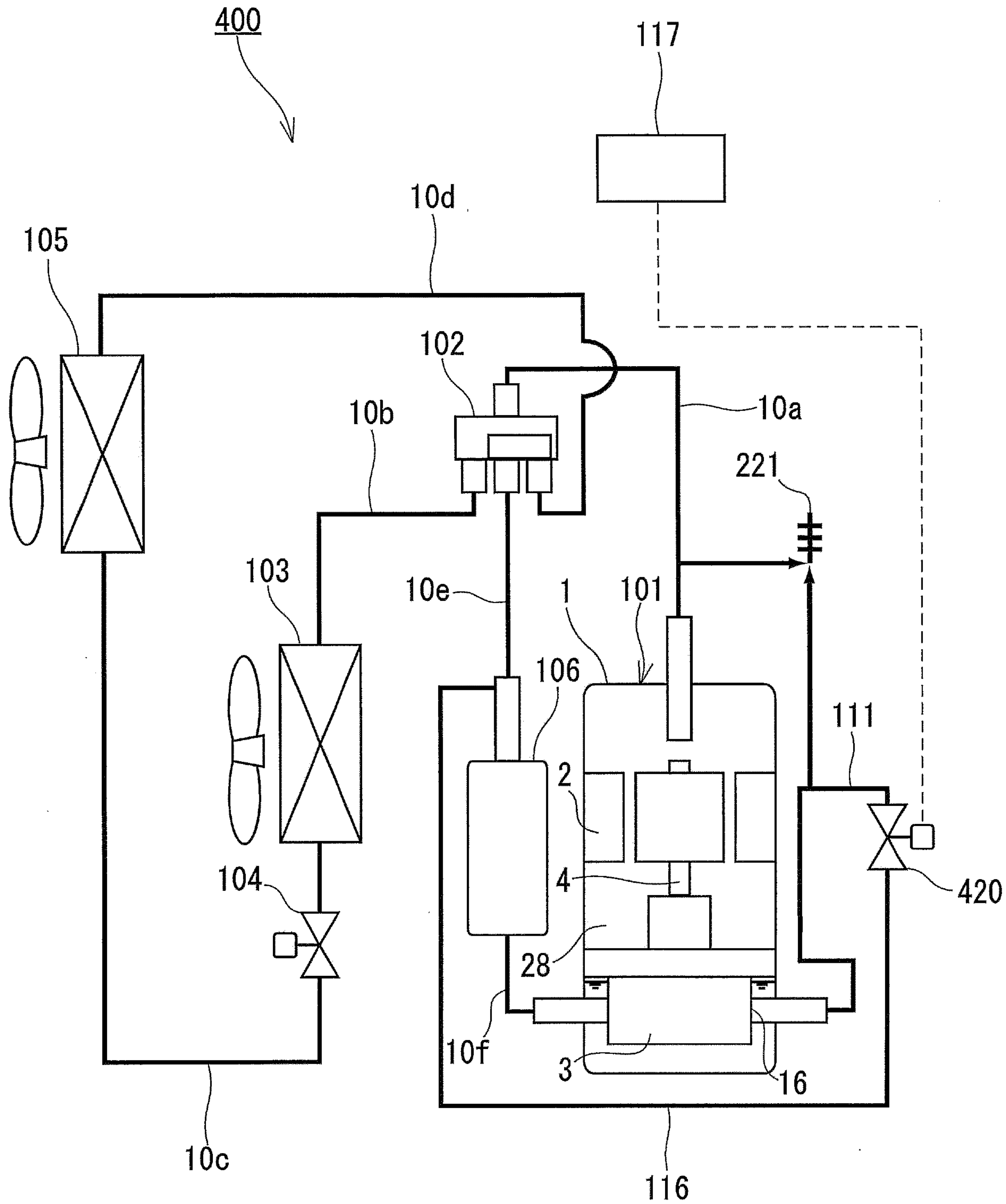
400
117
10d
105
102
10b
10a
221
103
10e
1
101
106
111
2
4
104
420
28
10f
3
16
10c
116

FIG.7

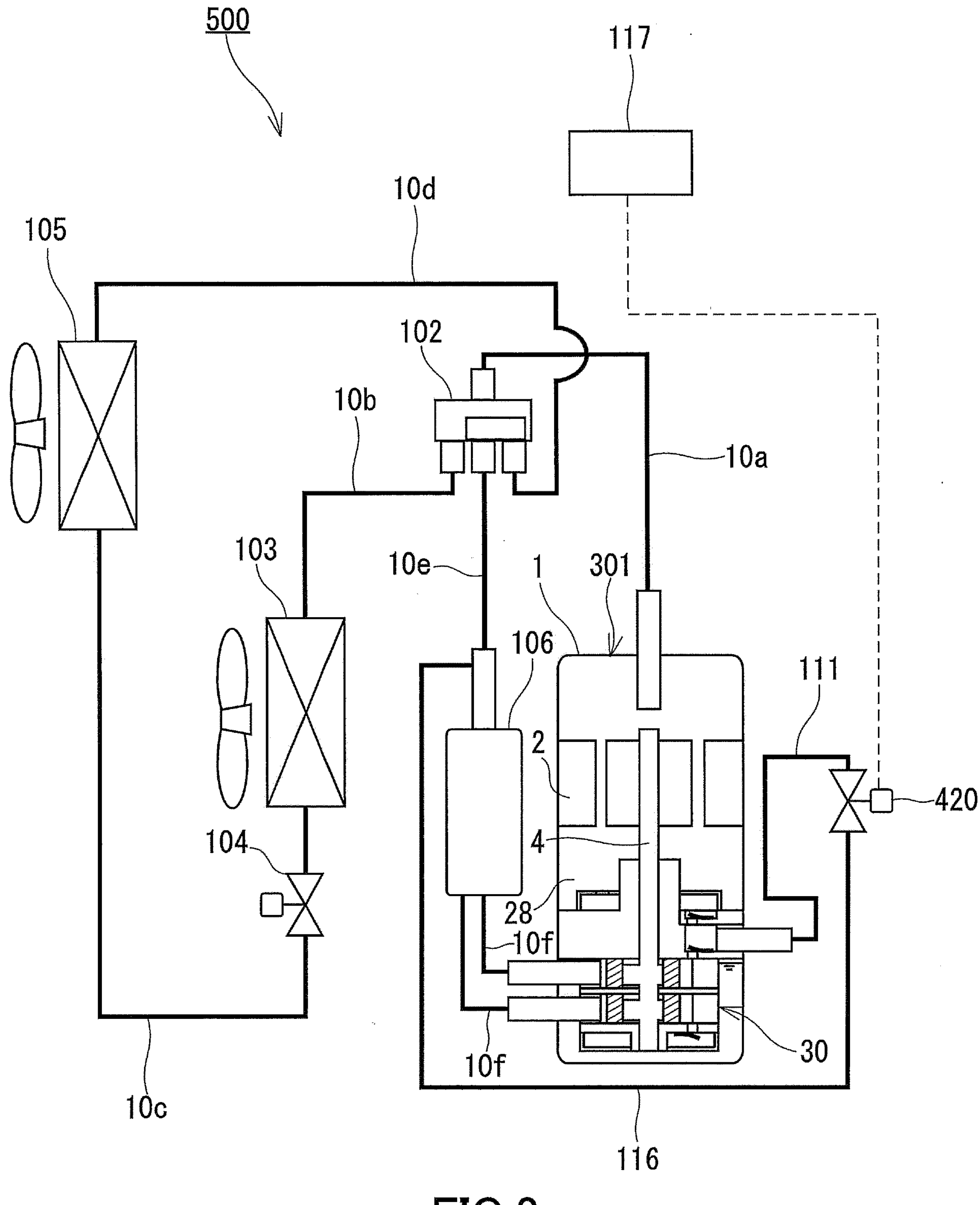
500
117
10d
105
102
10b
10a
103
10e
1
301
106
111
2
420
4
104
28
10f
10f
30
10c
116

FIG.8

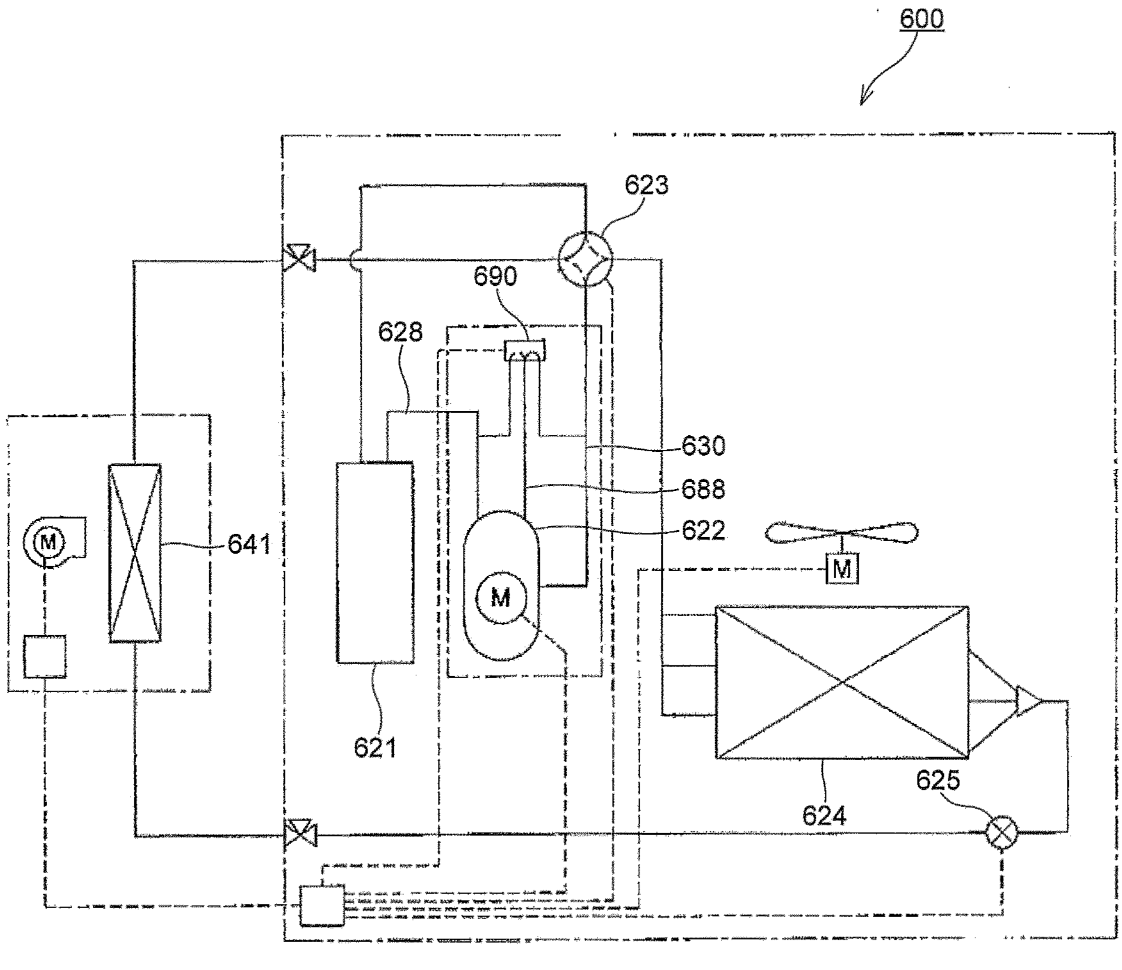

FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/003430

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F04C28/00*(2006.01)i, *F04C28/26*(2006.01)i, *F04C29/12*(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)
F25B1/00, F04C28/00, F04C28/26, F04C29/12

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
Y	JP 2-191882 A (Hitachi, Ltd.), 27 July 1990 (27.07.1990), page 2, lower right column, line 9 to page 5, upper left column, line 1; fig. 1 to 3 (Family: none)	1-10
Y	JP 5-164416 A (Sanyo Electric Co., Ltd.), 29 June 1993 (29.06.1993), paragraph [0016]; fig. 1 (Family: none)	1-10

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 August, 2012 (14.08.12)	21 August, 2012 (21.08.12)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/003430

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3-164579 A (Matsushita Electric Industrial Co., Ltd.), 16 July 1991 (16.07.1991), page 3, upper right column, lines 5 to 16; page 4, lower right column, lines 6 to 10; fig. 1 to 2 (Family: none)	1-10
Y	JP 2010-156244 A (Daikin Industries, Ltd.), 15 July 2010 (15.07.2010), paragraphs [0121] to [0128]; fig. 11 (Family: none)	2,4-10
Y	JP 3-175230 A (Daikin Industries, Ltd.), 30 July 1991 (30.07.1991), page 6, lower right column, line 4 to page 7, upper right column, line 7 (Family: none)	5,6,9,10
Y	JP 2009-24929 A (Mitsubishi Electric Corp.), 05 February 2009 (05.02.2009), paragraphs [0027] to [0028]; fig. 14 (Family: none)	6,10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008240699 A **[0005] [0034]**