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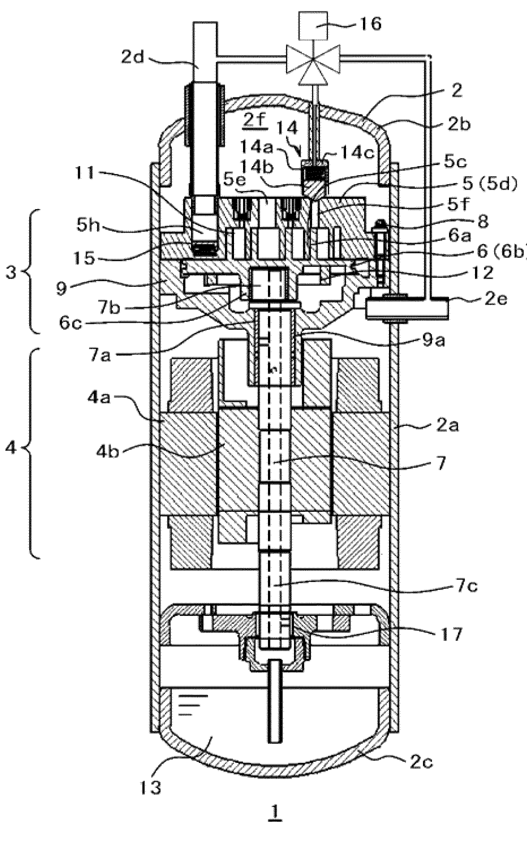
# (54) SCROLL COMPRESSOR


(57) A scroll compressor is provided with a fixed scroll 5 and an orbiting scroll 6 meshed with each other to form a compression room 11, the fixed scroll having a release port 5e with a discharge outlet formed toward the central part and causing the compression room and the discharge side to communicate with each other on the outer circumferential side and a release valve 5a for preventing a reverse flow from the discharge side toward the compression room, and on the outer circumferential side of the fixed scroll a suction room 10 and a suction passage 5h. Further in the fixed scroll, a bypass passage 5f that causes the discharge side to communicate with the suction room or the suction passage is formed, and a bypass valve 14 for opening and closing the bypass passage is provided. Farther upstream than the suction room or the suction passage into which the bypass passage opens, a suction non-return valve 15 to prevent flowing back to the upstream side is disposed. In this way, highly efficient capacity control can be realized even under a light load operating condition by improving the delay in the discharge of the refrigerant to the discharge side when capacity-controlled operation is switched over to normal operation.


FIG.1

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## Description

### Technical Field

**[0001]** The present invention relates to a scroll compressor, and more appropriately to a scroll compressor adaptable to operation in a wide range from heavy load to light load.

### Background Art

**[0002]** In recent years, from the viewpoint of reducing the consumption of energy consumed in residential houses, namely the energy consumed by air conditions and the energy consumed by water heaters, a tendency is intensifying to reduce consumed energy by using highly thermally insulative materials as insulative materials for buildings, reducing thermal loads by increasing airtightness or utilizing solar heat.

**[0003]** Against this background of thermal load decreases resulting from advanced thermal insulation and airtightness of houses, scroll compressors used in air conditioners and water heaters are required to permit capacity control over a broad range by each individual unit. For instance, when an air conditioner is used for space cooling, it has to operate quickly because the temperature in the room is usually high at the time of staring the operation.

**[0004]** In such a case, the conventional practice is to perform high-speed operation (high-speed rotation) with a larger capacity at the time of start by using inverter control and, when the room space is cooled to some extent and a shift to a regular operating state takes place, low-speed operation (low-speed rotation) with a smaller capacity is performed. However, the low-speed operation in the regular operating state would mean operation at a very low rotating speed if in particular a case is assumed in which the air conditioner installed in a building to which today's energy saving is applied and provided with highly insulative materials.

**[0005]** However, if a scroll compressor rotates at an excessively low speed, not only the inverter efficiency and the compressor efficiency will drop but also oil film ruptures in slide bearings will occur structurally, making the bearings susceptible to damage. Moreover, stable operational actions are made difficult, such as motor driving to turn the crankshaft is prevented from smooth operation on account of the low-speed rotation.

**[0006]** Hence, a usual practice is to keep the rotational speed at not too low a level at the time of small-capacity operation and to control the capacity; for instance, when the room space is cooled to a certain temperature, the scroll compressor is stopped, when the room temperature rises, it is started again, and this operational pattern is repeated.

**[0007]** However, as this operational pattern of repeating stop and start during small-capacity operation is not only inefficient but also unable to provide comfortable air conditioning, techniques to devise capacity control are proposed.

**[0008]** For instance, a structural improvement of part of a scroll compressor to accomplish control to make the discharge volume variable while keeping the rotational speed constant is described in Patent Literature 1 and elsewhere. According to what is described in Patent Literature 1, a bypass passage is provided to let refrigerant gas on the way of compression bypass to the suction side, an electromagnetic valve to open and close this bypass passage is further provided, and the refrigerant gas on the way of compression is discharged to the suction side by opening this electromagnetic valve to accomplish capacity control thereby to make the discharge volume variable.

### Citation List

#### Patent Literature

**[0009]**

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2004-143951

### Summary of Invention

#### Technical Problem

**[0010]** In what is described in Patent Literature 1 cited above, when capacity control is attempted by opening the electromagnetic valve, the compression room on the way of compression and the bypass passage communicate with the suction side to make the refrigerant of the suction pressure circulate, and the path of this circulation is under the suction pressure during capacity-controlled operation. On the other hand, during capacity-controlled operation, too, the discharge side (for instance the inside of the discharge chamber) of the scroll compressor is under the discharge pressure.

**[0011]** For this reason, when capacity-controlled operation is to be switched over to normal operation, since the compressed refrigerant can be discharged to the discharge side only after the suction pressure is raised to the discharge pressure in the compression room, the bypass passage and elsewhere, a time delay will result from the discharging of the refrigerant to the discharge side, resulting in a problem of a decrease in the circulating volume of the refrigerant. A decrease in the circulating volume of the refrigerant invites a drop in the work volume of compression relative to power consumption by the compressor and consequently a drop in compressor efficiency.

**[0012]** An object of the present invention is to obtain a scroll compressor that can realize highly efficient capacity control even under a light load operating condition by improving the delay in the discharge of the refrigerant to the discharge side when capacity- controlled operation is switched over to normal operation.

Solution to Problem

**[0013]** In order to achieve the object stated above, the invention provides a scroll compressor comprising a fixed scroll, an orbiting scroll disposed in a sealed vessel and meshed with each other to form a compression room, the fixed scroll having a release port with a discharge outlet formed toward the central part and causing the compression room and the discharge side to communicate with each other on the outer circumferential side and a release valve for preventing a reverse flow from the discharge side toward the compression room, and on the outer circumferential side of the fixed scroll a suction room and a suction passage communicating with the suction room, further provided with a bypass passage formed in the fixed scroll and causing the discharge side and the suction room or the suction passage to communicate with each other; a bypass valve for opening and closing this bypass passage; and a suction non-return valve that is disposed farther upstream from the suction room or part of the suction passage into which the bypass passage opens and prevents reverse flowing to the upstream side. Advantageous Effects of Invention

**[0014]** According to the invention, as the delay in the discharge of the refrigerant to the discharge side when capacity-controlled operation is switched over to normal operation can be improved, a scroll compressor that can realize highly efficient capacity control even under a light load operating condition can be obtained.

Brief Description of Drawings

**[0015]**

[Fig. 1] A longitudinal section showing a first embodiment of a scroll compressor according to the invention.

[Fig. 2] A bottom view of a fixed scroll of the scroll compressor shown in Fig. 1, also illustrating a lap of an orbiting scroll.

[Fig. 3] An enlarged view of an essential part of Fig. 2 illustrating the range of installation of a bypass passage.

[Fig. 4] A section of an essential part illustrating the action of the scroll compressor shown in Fig. 1 during normal operation (a bypass valve closed).

[Fig. 5] A section of the essential part illustrating the action of the scroll compressor shown in Fig. 1 during bypass operation (the bypass valve open).

[Fig. 6] A diagram illustrating the opening/closing control of the bypass valve in the first embodiment of the invention.

[Fig. 7] A diagram illustrating relations among the low pressure bypass valve aperture control, the compressor discharge flow rate, input and pressure according to prior art.

[Fig. 8] A diagram illustrating relations among the low pressure bypass valve aperture control, the compressor discharge flow rate, input and pressure in the first embodiment of the invention.

[Fig. 9] A sectional view of an essential part showing a second embodiment of a scroll compressor according to the invention.

[Fig. 10] A bottom view of a fixed scroll of the scroll compressor shown in Fig. 9, a counterpart to Fig. 2.

[Fig. 11] An enlarged view of an essential part showing the structure of the vicinities of the bypass valve in Fig. 9, illustrating actions in normal operation.

[Fig. 12] An enlarged view of the essential part showing the structure of the vicinities of the bypass valve in Fig. 9, illustrating a transitional state from normal operation to bypass operation.

[Fig. 13] An enlarged view of the essential part showing the structure of the vicinities of the bypass valve in Fig. 9, illustrating actions in bypass operation.

[Fig. 14] An enlarged view of the essential part showing the structure of the vicinities of the bypass valve in Fig. 9, illustrating a transitional state from bypass operation to normal operation.

[Fig. 15] A diagram illustrating relations among bypass valve aperture variations, pressure variations in the bypass valve space and pressure variations in the suction room to the aperture control of a switch valve in the second embodiment of the invention.

Description of Embodiments

**[0016]** Specific embodiments of the present invention will be described in detail below with reference to the drawings.

First Embodiment

**[0017]** The first embodiment of the invention will be described with reference to Fig. 1 through Fig. 8. Fig. 1 is a longitudinal section showing the first embodiment of the scroll compressor according to the invention. A scroll compressor 1 is configured of, among others, a compressing mechanism part 3 composed by meshing a fixed scroll 5 and an orbiting scroll 6 with each other, an electric motor 4 driving this compressing mechanism part 3, and a sealed vessel 2 housing the compressing mechanism part 3, the electric motor 4 and the like.

**[0018]** In the sealed vessel 2, the compressing mechanism part 3 and the electric motor 4 are arranged in the upper part and the lower part, respectively, and further in the bottom part an oil sump 13 in which lubricating oil is deposited is provided. Also the sealed vessel 2, is configured of a cylindrically shaped case 2a making up the trunk, a lid chamber 2b welded to the upper part of this case 2a, and a bottom chamber 2c welded to the lower part of the case 2a. A suction pipe 2d is fitted to the lid chamber 2b, a discharge pipe 2e is fitted to the case 2a, and the inside of the sealed vessel 2 makes up a discharge chamber 2f.

**[0019]** The compressing mechanism part 3 is configured of, among others, the fixed scroll 5 having a spirally shaped lap 5c erected on a panel plate 5d, the orbiting scroll 6 having a spirally shaped lap 6a erected on a panel plate 6b, and a frame 9 that is integrally fixed to the fixed scroll 5 with a bolt 8 and supports the orbiting scroll 6. Further, 7 denotes a crankshaft that is rotatably supported by a main bearing 9a disposed in the frame 9, and an eccentric part 7b is linked to the orbiting scroll 6 via an orbiting bearing 6c disposed on a boss part of the rear face of the orbiting scroll 6.

**[0020]** Further, an Oldham's ring 12 is disposed between the under face of the orbiting scroll 6 and the frame 9, and this Oldham's ring 12 is engaged with a groove formed in the under face of the orbiting scroll 6 and a groove formed in the frame 9 and causes the orbiting ring 6, without allowing it to rotate, to perform revolving (orbiting) motion in response to eccentric turning of the eccentric part 7b of the crankshaft 7.

**[0021]** The electric motor 4 is provided with a stator 4a and a rotor 4b; the stator 4a is fixed to the sealed vessel 2 by such means as pressing in or welding, and the rotor 4b is fixed to the crankshaft 7 and arranged rotatably within the stator 4a.

**[0022]** The crankshaft 7, configured of a main shaft part 7a and the eccentric part 7b, is supported by the main bearing 9a disposed in the frame 9 and a sub-bearing 17 fitted to the case 2a of the sealed vessel 2. The eccentric part 7b is formed eccentrically relative to and integrally with the main shaft part 7a of the crankshaft 7, and is inserted into and engaged with the orbiting bearing 6c provided on the rear face of the orbiting scroll 6. Further, the crankshaft 7, driven by the electric motor 4, causes the orbiting scroll 6 to orbit by eccentrically rotating the eccentric part 7b.

In the crankshaft 7, there is formed an oiling passage 7c for guiding lubricating oil 13 to the main shaft part 7a, the sub-bearing 17, the orbiting bearing 6c and elsewhere.

**[0023]** Refrigerant gas of the freezing cycle, when the orbiting scroll 6 is caused to orbit by the electric motor 4 via the crankshaft 7, is introduced from the suction pipe 2d into a compression room 11 partitioned by the fixed scroll 5 and the orbiting scroll 6, and is compressed by the contraction of the volume of the compression room 11 as it shifts toward the center of the spirally shaped laps 5c and 6a. The compressed refrigerant gas is discharged from a discharge port 53 provided substantially at the center of a panel plate 5d of the fixed scroll 5 into the discharge chamber 2f within the sealed vessel 2, and flows out (toward the condenser of the freezing cycle) from the discharge pipe 2e.

**[0024]** Next, the configuration of the fixed scroll 5 will be described with reference to Fig. 2 through Fig. 4. Fig. 2 is a bottom view of the fixed scroll 5, also illustrating the lap 6a of the orbiting scroll 6; Fig. 3, an enlarged view of the vicinities of the suction room in Fig. 2; and Fig. 4, a section of an essential part illustrating on an enlarged scale the vicinities of the compressing mechanism part 3 of the scroll compressor shown in Fig. 1.

**[0025]** As shown in these drawings, in this embodiment, a release port 5b that causes the compression room 11 to communicate with the discharge chamber 2f, which is the discharge side, and a bypass passage 5f that causes the suction room 10 to communicate with the discharge chamber 2f is formed; the release port 5b is provided with a release valve 5a, which is a non-return valve to prevent flowing back from the discharge side to the compression room 11; and the bypass passage 5f is provided with a bypass valve 14 for opening and closing the bypass passage 5f. Further, upstream from the suction room 10 with which the bypass passage 5f communicates, a suction passage 5h is disposed, and farther upstream from this suction passage 5h, a suction non-return valve 15 is disposed. This suction non-return valve 15 has to be disposed farther upstream than the suction room 10 or the suction passage 5h into which the bypass passage 5f opens, and is intended to prevent flowing back to the upstream side (evaporator side).

**[0026]** In Fig. 3, which is an enlarged view of the vicinities of the suction room, a lap position 6a1 of the lap 6a of the orbiting scroll 6 at the moment of completion of suction by an outer line side compression room 21 and a lap position 6a2 of the same at the moment of completion of suction by an inner line side compression room 22 are shown, one superposed over the other virtually. It is preferable for the opening of the bypass passage 5f on the suction room side to be in a position not communicating with the suction space represented by halftone dot meshing in Fig. 3, namely the compression room after the completion of suction by the outer line side compression room 21 and the inner line side compression room 22, but communicating with the suction space all the time or at least communicating immediately before the completion of suction by the compression room. This is intended to prevent the pressure in the compression room at the time of the completion of suction from being reduced by insufficient suction and re-compression which would follow from inviting generation of unnecessary motive power. In particular, as shown in section A of Fig. 2, in order to secure a cross-sectional area of the suction channel during normal operation, it is desirable, if the fixed scroll has a dug-in part deeper than the panel face, to dispose the opening of the bypass passage 5f in this dug-in part A.

**[0027]** The bypass valve 14 is provided with a valve element 14b for opening and closing the bypass passage 5f, a space 14a disposed on the rear face side (the side reverse to the fixed scroll 5) to cause the valve element 14b to work, and a spring 14c disposed in this space 14a. Further, the space 14a is provided with a communicating pipe 23 to be communicating with the suction pipe 2d (suction side) and the discharge pipe 2e (discharge side), and further a three-way valve 16 is provided on the way of this communicating pipe 23 in a part outside the sealed vessel 2. It is so configured that, by controlling this three-way valve 16, the refrigerant under the suction pressure or the discharge pressure can be selectively switched over at any desired timing and introduced into the space 14a on the rear face of the valve element 14b. The configuration is such that, when the refrigerant under the suction pressure is introduced, the valve element 14b so works as to open the bypass passage 5f with the difference in pressure working on the valve element 14b and the spring 14c or, when the refrigerant under the discharge pressure is introduced, the valve element 14b so works as to close the bypass passage 5f.

**[0028]** To add, though the destination of connection of the communicating pipe 23 is switched over with the three-way valve 16 in this embodiment, this is not the only way, but any configuration is acceptable if the bypass valve 14 is opened and closed by switching over the destination of connection of the space 14a to the suction side or the discharge side of the compressor and thereby introducing the refrigerant under the suction pressure or the discharge pressure into the space 14a; for instance the configuration may as well use a plurality of electromagnetic valves.

**[0029]** Fig. 4 shows the state of the scroll compressor 1 in normal operation (the bypass valve closed), namely a state in which the space 14a communicates with the discharge pipe 2e and filled with the refrigerant under the discharge pressure and the bypass valve 14 is closed. Arrows in Fig. 4 represent flows of the refrigerant. During normal operation with the bypass valve 14 closed, the refrigerant passes the suction pipe 2d, is sucked from the suction room 10 into the compression room 11 formed by meshing of the fixed scroll 5 and the orbiting scroll 6; contraction of the volume of this compression room 11 while shifting toward the center of spiral scroll laps compresses the refrigerant to be discharged from a discharge outlet 5e to the discharge chamber 2f. The refrigerant in the discharge chamber 2f further passes the discharge pipe 2e and is discharged out of the compressor (out of the sealed vessel).

**[0030]** Fig. 5 shows the state of the scroll compressor in bypass operation (the bypass valve open), namely a state in which the space 14a is continuous to the suction pipe 2d and filled with the refrigerant under the suction pressure and the bypass valve 14 is open. Arrows in Fig. 5 represent flows of the refrigerant. During bypass operation with the bypass valve 14 open, the discharge chamber 2f and the suction room 10 communicate with each other via the bypass passage 5f. As the suction room 10 is under the suction pressure when the bypass valve14 is closed, opening of the valve causes the refrigerant in the discharge chamber 2f to flow into the suction room 10, and the suction room 10 is placed under the discharge pressure. Namely, as the suction non-return valve 15 is provided between the suction room 10 and the suction pipe 2d, when the refrigerant in the discharge chamber 2f flows into the suction room 10, the suction non-return valve 15 is closed by the pressure difference between before and after it and closes the suction passage 5h. As the refrigerant in the discharge chamber 2f having flowed from the discharge chamber 2f into the suction room 10 can be prevented from flowing back from the suction room 10 side to the suction pipe 2d side, the suction room 10 is placed under the discharge pressure.

**[0031]** On the other hand, as the eccentric rotation of the orbiting scroll is continuing in that while, the refrigerant under the discharge pressure is sucked into the compression room 11 and compression starts, but, as the pressure of the refrigerant sucked into the compression room 11 is the discharge pressure from the beginning, there is no pressure difference between the discharge chamber 2f and the compression room 11. Therefore, only a slight compression of the refrigerant in the compression room 11 causes the release valve 5a to open, and a channel for the refrigerant in the compression room to be bypassed from the release port 5b to the discharge chamber 2f is formed. A bypass circulation for the refrigerant discharged into the discharge chamber 2f to return to the suction room 10 past the release port 5b is formed. During this bypass operation, the refrigerant is hardly compressed and discharged into the discharge chamber 2f through the release port 5b, and little motive power is therefore needed to compress the refrigerant.

**[0032]** Fig. 6 illustrates the opening/closing control of the bypass valve 14 when capacity control is done in the scroll compressor of this embodiment. As shown in this drawing, the bypass valve 14 repeats opening and closing in a constant cycle. Normal operation and bypass operation, mentioned earlier, are thereby periodically switched over to each other to enable the average discharge flow rate of the compressed refrigerant to be reduced while keeping the compressive power at the necessary minimum.

**[0033]** The opening/closing control of the bypass valve 14 in this embodiment is so configured as to regulate steplessly the capacity at any desired level between 0 and 100% by making the time ratio between the open and closed states in one open/closed cycle variable. If, for instance, the open period of the bypass valve per cycle is 40% of the whole cycle duration, the capacity will be 60%. To add, the open/closed cycle may be constant, but it is desirable to make the cycle duration variable according to the time ratio between the open and closed states.

**[0034]** Next, advantageous effects of this embodiment will be described.

First, for the purpose of comparison, actions in a prior art scroll compressor, such as the one revealed in Patent Literature 1, will be described. In the compressor of Patent Literature 1, a low-pressure bypass valve (156) and a high-pressure bypass valve (157) perform the role of switching over between normal operation and bypass operation. During normal operation, the low-pressure bypass valve (156) is closed, and compressed refrigerant is discharged toward the discharge side 109B past a discharge pipe or a high-pressure side bypass passage BH.

**[0035]** On the other hand, during bypass operation, the low-pressure bypass valve (156) is opened in a state in which the high-pressure bypass valve (157) is closed. This causes a space disposed in the upper part of the fixed scroll (a bypass mechanism (140) that bypasses fluid present in the intermediate area between the suction side and the discharge side) to be connected to the suction side to be placed under the suction pressure thereby to open a bypass valve (146) to be opened by the differential pressure, and the refrigerant in the compression room to be discharged to the suction side almost uncompressed. In this way, in the conventional case described above, the compression room is substantially filled with the suction pressure during bypass operation.

**[0036]** This embodiment significantly differs from the foregoing case in that both the suction room 10 and the compression room 11 are substantially filled during bypass operation with the discharge pressure.

In this way, in a scroll compressor that performs operation in which the refrigerant is bypassed (bypass operation), a space in which the pressure differs between normal operation and bypass operation is present including the compression room.

**[0037]** Fig. 7 is a diagram illustrating relations among the low pressure bypass valve aperture control, the compressor discharge flow rate, input and pressure according to prior art. In Fig. 7, "Bypass pressure" is the pressure in the space in which the pressure varies during bypass operation (hereinafter referred to as the bypass space), which in the above-cited prior art is the pressure in the space of the bypass mechanism (140) and the bypass passage BH.

**[0038]** In Fig. 7, the horizontal axis represents the lapse of time; along this lapse of time, relations among the discharge flow rate of the compressed refrigerant relative to the actions of the bypass valve and the compressor input and pressure will be described on a time series basis.

First, during normal operation during which the low-pressure bypass valve (156) is closed and the high-pressure bypass valve (157) is open, the refrigerant is normally compressed and discharged, and accordingly the required discharge flow rate is obtained. Further, a normal compressor input is required as motive power for compressing the refrigerant. At this time, the bypass pressure (the pressure in the bypass space) is the same as the discharge pressure.

**[0039]** Next, when switching over to bypass operation in which the low-pressure bypass valve (156) is open and the high-pressure bypass valve (157) is closed takes place, the compression room is filled with the refrigerant under the suction pressure by communicating with the suction side. Also, the bypass space is placed under the suction pressure by communicating with the suction side.

**[0040]** When a further period of time passes and normal operation is resumed, closure of the low-pressure bypass valve causes compression to start, but re-compression is required because the pressure in the bypass space then has dropped to the suction pressure level. For this reason, compression of the refrigerant to or above the pressure on the discharge side takes time, and a time delay arises from the closing of the low-pressure bypass valve until the discharging of the refrigerant, which invites a discharge delay and a decrease in discharge flow rate relative to the compressor input. Thus, the prior art product involves the problem of entailing a drop in compressor efficiency during operation under capacity control.

**[0041]** Fig. 8 is a diagram illustrating relations among the bypass valve aperture control, the discharge flow rate of the compressed refrigerant, the compressor input and pressure in this embodiment. For this Fig. 8, description will be dispensed with regarding the same parts as in Fig. 7.

In this embodiment, the bypass space comprises the suction room 10, the compression room 11 and the bypass passage 5f, and "Bypass pressure" is the pressure in the suction room 10 and the bypass passage 5f.

**[0042]** The diagram of Fig. 8 will be described along a time series. First, during normal operation with the bypass valve 14 closed, as the refrigerant is normally compressed and discharged, it is obtained at the required flow rate. Also, the normal compressor input is required as motive power for compressing the refrigerant. At this time, the bypass pressure (the pressure in the bypass space) is the same as the suction pressure.

**[0043]** Next, when the bypass valve 14 is opened and switching over to bypass operation takes place, the suction room 10 communicates with the discharge chamber 2f, the suction room 10 and the bypass passage 5f are filled with the discharge pressure, and the compression room 11 is also placed under the discharge pressure. Thus it is a significant feature of this embodiment that the bypass pressure becomes substantially equal to the discharge pressure during bypass operation.

**[0044]** When a further period of time passes, the bypass valve 14 is closed, and normal operation is resumed; as the compression room 11 is already filled with the refrigerant under the discharge pressure, there is no need for re-compression, but discharging of the refrigerant can be immediately started, and the normal discharge volume can be secured. Thus, as this embodiment takes no long time to compress the refrigerant to or above the pressure level on the discharge side and discharge it and therefore can eliminate discharge delays, the discharge flow rate relative to the compressor input during operation under capacity control can be prevented from decreasing and thereby inviting a drop in compressor efficiency. Therefore, as the discharge volume can be increased to a higher level than by the prior art, the compressor efficiency during operation under capacity control can be enhanced.

**[0045]** As hitherto described, this embodiment can prevent the compressor input during operation under capacity control from falling and moreover, it can regulate steplessly the capacity at any desired level between 0 and 100% by making variable the time ratio between the open and closed states in one open/closed cycle of the bypass valve 14, thereby enabling a scroll compressor that can realize high-efficiency capacity control even under low-speed and light-load operating conditions to be obtained.

**[0046]** Also, as capacity control by this embodiment switches over between normal operation and bypass operation at a constant time ratio, not only the capacity can be made steplessly variable in a broad range of 0 to 100% by regulating the time ratio but also the scroll compressor can be used under rotational speed conditions that permit high-efficiency and high-reliability operation.

Second Embodiment

**[0047]** Next, a second embodiment of a scroll compressor according to the invention will be described with reference to Fig. 9 through Fig. 15. To add, parts assigned the same reference signs in Fig. 9 through Fig. 15 as in Fig. 1 through 8 denote respectively the same or corresponding parts.

Fig. 9 is a sectional view of the vicinities of the compression mechanism part of the scroll compressor, showing the second embodiment of the invention, and Fig. 10, a bottom view of a fixed scroll of the scroll compressor shown in Fig. 9, also showing orbiting scroll laps.

**[0048]** While the opening/closing control of the bypass valve 14 is accomplished by utilizing the pressure of the refrigerant flowing through the suction pipe 2d and the discharge pipe 2e in the first embodiment described above, in this second embodiment the opening/closing control of the bypass valve 14 is accomplished by utilizing pressure variations in the suction room 10.

**[0049]** As shown in Fig. 9, in this embodiment, too, like in the first embodiment, the fixed scroll 5 is provided with the bypass passage 5f that connects the suction room 10 and the discharge chamber 2f, and an opening on the discharge chamber side of this bypass passage 5f is provided with the bypass valve 14. This bypass valve 14 is provided with the valve element 14b for opening and closing the bypass passage 5f, the space 14a on the rear face (the reverse side to the fixed scroll 5) of this valve element 14b, and the spring 14c disposed in this space 14a.

**[0050]** Further, the space 14a is so configured as to communicate with the suction room 10 via a switching valve passage 5g formed in the fixed scroll 5. Also, on the aperture of the switching valve passage 5g on the discharge chamber 2f side a switching valve 18 for opening and closing this aperture is provided; the configuration is such that, when this switching valve 18 is opened, the space 14a communicates with the suction room 10 and, when the switching valve 18 is closed, the communication of the space 14a with the suction room 10 is cut off. The switching valve 18 is provided with a valve element 18a for opening and closing the switching valve passage 5g, a spring 18b that presses the valve element 18a toward the switching valve passage 5g, and a coil 18c for causing the valve element 18a to perform opening or closing.

**[0051]** When electricity is supplied to the coil 18c of the switching valve 18, a magnetic field is generated in the central part of the coil, the valve element 18a made of iron or the like of the switching valve is drawn by the magnetic force to float, and the valve element 18a opens. On the other hand, if no electricity is supplied to the coil, the valve element 18a is pressed toward the fixed scroll 5 by the force of the spring 18b to block the switching valve passage 5g.

**[0052]** As the switching valve passage 5g is used only for letting the refrigerant flow into the space 14a of the small-volume bypass valve 14 or letting it flow out of the space 14a, its passage area can be made very small and, as the pressure of the refrigerant on the valve element 18a is also small, the valve element 18a can be easily opened or closed.

**[0053]** As shown in Fig. 10, the bypass passage 5f is disposed in a similar position to that in the first embodiment shown in Fig. 2, and the switching valve passage 5g is disposed in a similar range to the destination range of connection of the suction room side opening of the bypass passage 5f represented by halftone dot meshing in Fig. 3. The switching valve passage 5g is connected to the space 14a in the bypass valve 14, can open or close the switching valve by turning on or off the current to the coil of the switching valve 18, and can switch over between communication and non-communication of the switching valve passage 5g.

Description of other configurations is omitted because they are similar to those of the first embodiment.

**[0054]** Next, the actions of this second embodiment will be described with reference to Fig. 11 through Fig. 15. Fig. 11 through Fig. 14 are enlarged views of the structures of the vicinities of the bypass valve in Fig. 9; Fig. 11 shows the state during normal operation, Fig. 12, the transitional state from normal operation to Fig. 13, the state during bypass operation, and Fig. 14, the transitional state from bypass operation to normal operation.

**[0055]** At the time of starting the scroll compressor, the bypass valve 14 and the switching valve 18 are in the state shown in Fig. 11. Thus, as the pressure in the compressor is uniform at the time of start, the valve element 18a is pressed toward the fixed scroll 5 by the force of the spring 18b and closes the valve by blocking the switching valve passage 5g. As the pressure in the suction room falls along with the operation of the compressor, the bypass valve 14 is held in the closed state by the pressure difference between the space 14a on its rear face side and the suction room 10 side.

**[0056]** When, from the state of Fig. 11, electricity is supplied to the coil 18c of the switching valve 18 for a short period of time, the valve element 18a rises as long as electricity is supplied, and the switching valve 18 opens. When the switching valve 18 opens, the suction room 10 and the space 14a of the bypass valve 14 communicate with each other, and the space 14a is placed under the suction pressure. Also at this time, as the inside of the discharge chamber 2f is under the discharge pressure, the discharge pressure works on the part indicated by A in Fig. 12. Therefore, the valve element 14b is lifted by the pressure difference; as shown in Fig. 13, the bypass valve 14 opens, the discharge chamber 2f and the suction room 10 communicate with each other, and bypass operation during which the refrigerant under the discharge pressure in the discharge chamber 2f flows into the suction room 10 via the bypass passage is started. To add, as the supply of electricity to the switching valve 18 is only for a short period, the switching valve 18 is immediately closed as shown in Fig. 13. For this reason, during the bypass operation, the pressure in the space 14a remains to be kept at the suction pressure level.

**[0057]** In this state of bypass operation, as the refrigerant of the discharge chamber 2f is flowing into the suction room 10, the discharge pressure is maintained. Next, when from this state of bypass operation, electricity is supplied again to the switching valve 18 for a short period of time, the switching valve 18 opens to take on the state shown in Fig. 14. For this reason, the refrigerant under the discharge pressure in the suction room 10 flows into the space 14a of the bypass valve 14 to place the space 14a under the discharge pressure, and the pressures working on the upper and lower faces of the valve element 14b are balanced. As the valve element 14b is given a force by the spring 14c in the direction of closing the valve element 14b, the valve element 14b blocks the bypass passage 5f, and the bypass valve 14 is closed. As the supply of electricity to the switching valve 18 is only for a short period, switching over to normal operation shown in Fig. 11 takes place, and the scroll compressor starts normal compressive actions.

**[0058]** Fig. 15 is a diagram illustrating relations among bypass valve aperture variations the switching valve 18, pressure variations in the space 14a of the bypass valve 14 and pressure variations in the suction room 10 in response to the aperture control of the switch valve 18 in this second embodiment.

**[0059]** As shown in this Fig. 15, by repeating the actions described above, the scroll compressor can be operated under capacity control. Thus, when electricity is supplied to the switching valve 18 and the switching valve is opened for a short period of time, the pressure in the space 14a of the bypass valve 14 varies from the discharge pressure to the suction pressure; as the bypass valve 14 is thereby closed, the suction room 10 is placed under the discharge pressure to accomplish bypass operation. When electricity is supplied again to the switching valve 18 and the switching valve is opened for a short period of time, the pressure in the space 14a of the bypass valve 14 varies from the suction pressure to the discharge pressure; thereby the bypass valve 14 is closed, the suction room 10 is placed under the suction pressure to return to normal operation. Therefore, by controlling the opening and closing of the switching valve 18, operation under duty capacity control, by which the duration of normal operation and that of bypass operation are controlled, is made possible. Therefore, in this second embodiment too, the discharge volume can be freely regulated by controlling the ratio between the duration of normal operation and that of bypass operation (duty ratio), making possible operation under capacity control.

**[0060]** Further, as the suction room 10 can be kept under the discharge pressure during bypass operation in this embodiment, too, discharge can be started immediately after closing the bypass valve 14 when switching over to normal operation, and any delay in the discharge of the refrigerant to the discharge side at the time of switching over to normal operation can be improved. In this way, it is made possible to obtain a scroll compressor that can realize high-efficiency capacity control even under light-load operating conditions.

**[0061]** Not only similar effects to the above-described first embodiment can be obtained in this embodiment, too, but also this embodiment allows arrangement of the bypass valve 14 and the switching valve 18, both needed for bypass operation, in the sealed vessel 2. Therefore, as structural components including the communicating pipe 23 and the three-way valve 16 disposed outside the sealed vessel 2, such as the one shown in the first embodiment, become dispensable, there is a further advantageous effect of making possible manufacture of compact products at low cost.

List of Reference Signs

**[0062]**

1: Scroll compressor
2: Sealed vessel (2a: case, 2b: lid chamber, 2c: bottom chamber,
2d: suction pipe, 2e: discharge pipe, 2f: discharge chamber)
3: Compressing mechanism part
4: Electric motor 4 (4a: stator, 4b: rotor)
5: Fixed scroll (5a: release valve, 5b: release port, 5c: lap,
5d: panel plate, 5e: discharge outlet, 5f: bypass passage, 5g: switching valve passage, 5h: suction passage), 6: Orbiting scroll (6a: lap, 6b: panel plate, 6c: orbiting bearing)
7: Crankshaft (7a: main shaft part, 7b: eccentric part, 7c: oiling passage)
8: Bolt
9: Frame (9a: main bearing)
10: Suction room
11: Compression room
12: Oldham's ring
13: Oil sump
14: Bypass valve (14a: space, 14b: valve element, 14c: spring)
15: Suction non-return valve
16: Three-way valve
17: Sub-bearing
18: Switching valve (18a: valve element, 18b: spring,

18c: coil)
21: Outer line side compression room, 22: Inner line side compression room
23: communicating pipe

## Claims

1. A scroll compressor comprising a fixed scroll, an orbiting scroll disposed in a sealed vessel and meshed with each other to form a compression room, the fixed scroll having a release port with a discharge outlet formed toward the central part and causing the compression room and the discharge side to communicate with each other on the outer circumferential side and a release valve for preventing a reverse flow from the discharge side toward the compression room, and on the outer circumferential side of the fixed scroll a suction room and a suction passage communicating with the suction room, further provided with:

   a bypass passage formed in the fixed scroll and causing the discharge side and the suction room or the suction passage to communicate with each other;
   a bypass valve for opening and closing this bypass passage; and
   a suction non-return valve that is disposed farther upstream from the suction room or part of the suction passage into which the bypass passage opens and prevents reverse flowing to the upstream side.

2. The scroll compressor according to Claim 1, wherein the bypass valve is provided with a valve element for opening and closing the bypass passage, a space that is disposed on the rear side of this valve element and causes the valve body to operate, and a spring disposed in this space.

3. The scroll compressor according to Claim 2, wherein a communicating pipe for communication with the suction side and the discharge side of the compressor is connected to the space for causing the valve element disposed in the bypass valve to operate, and refrigerant under the suction pressure or the discharge pressure is introduced into the space by switching over the destination of connection of the space to the suction side or the discharge side of the compressor thereby to open or close the bypass valve.

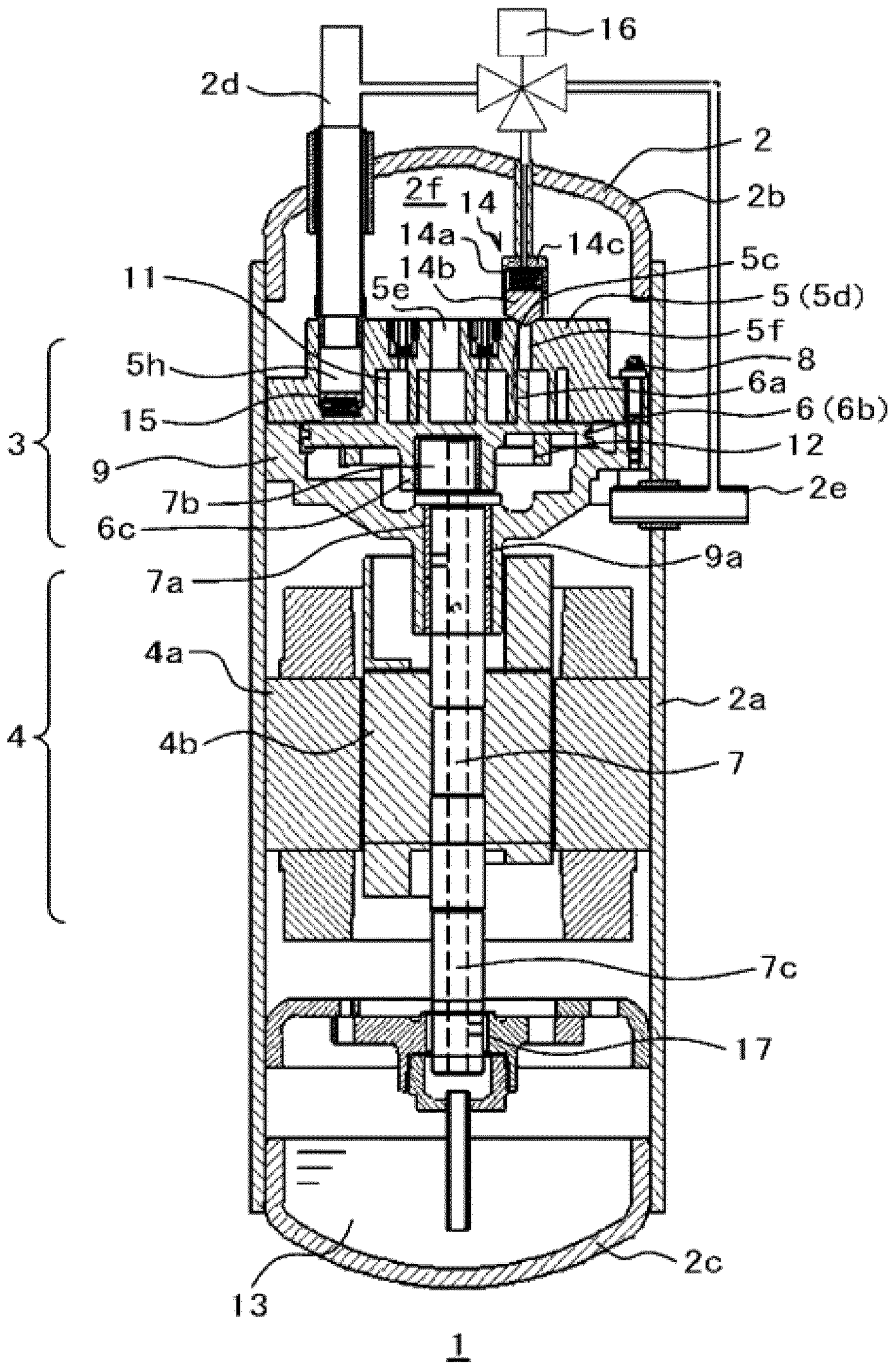
4. The scroll compressor according to Claim 3, wherein control to any desired capacity is accomplished by making the time ratio between the open and closed states in one open/closed cycle of the bypass valve variable.

5. The scroll compressor according to Claim 2, wherein the space for causing the valve element disposed in the bypass valve to operate is so configured as to communicate with the suction room via a switching valve passage formed in the fixed scroll, and a switching valve for opening and closing the switching valve passage.

6. The scroll compressor according to Claim 5, wherein the switching valve is provided with a valve element for opening and closing the switching valve passage, a spring that presses the valve element 18a, and a coil for causing the valve element to perform opening or closing.

7. The scroll compressor according to Claim 5, wherein the duration of normal operation and the duration of bypass operation are regulated by controlling the opening and closing of the switching value, and control to any desired capacity is accomplished by regulating the ratio between the duration of normal operation and the duration of bypass operation.

FIG. 1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2f
14
2b
14a
14c
14b
5c
11
5e
5 (5d)
5f
5h
8
6a
15
6 (6b)
3
12
9
2e
7b
6c
9a
7a
4a
2a
4
4b
7
7c
17
13
2c
1

FIG. 2

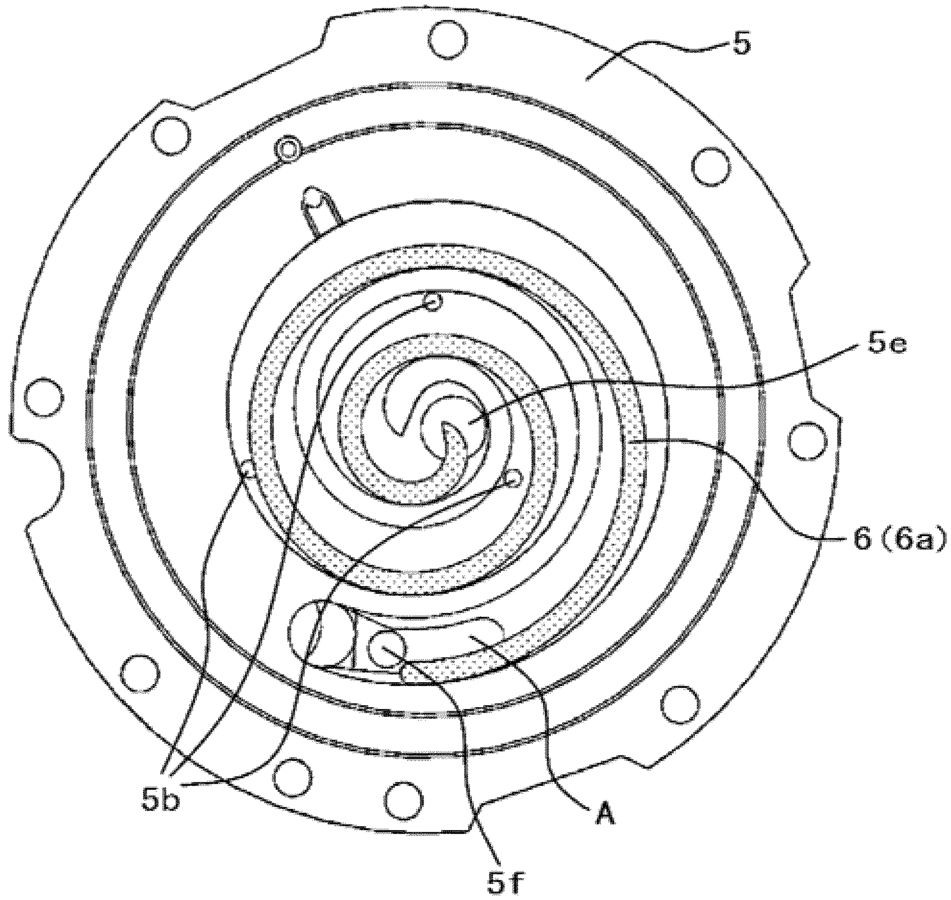
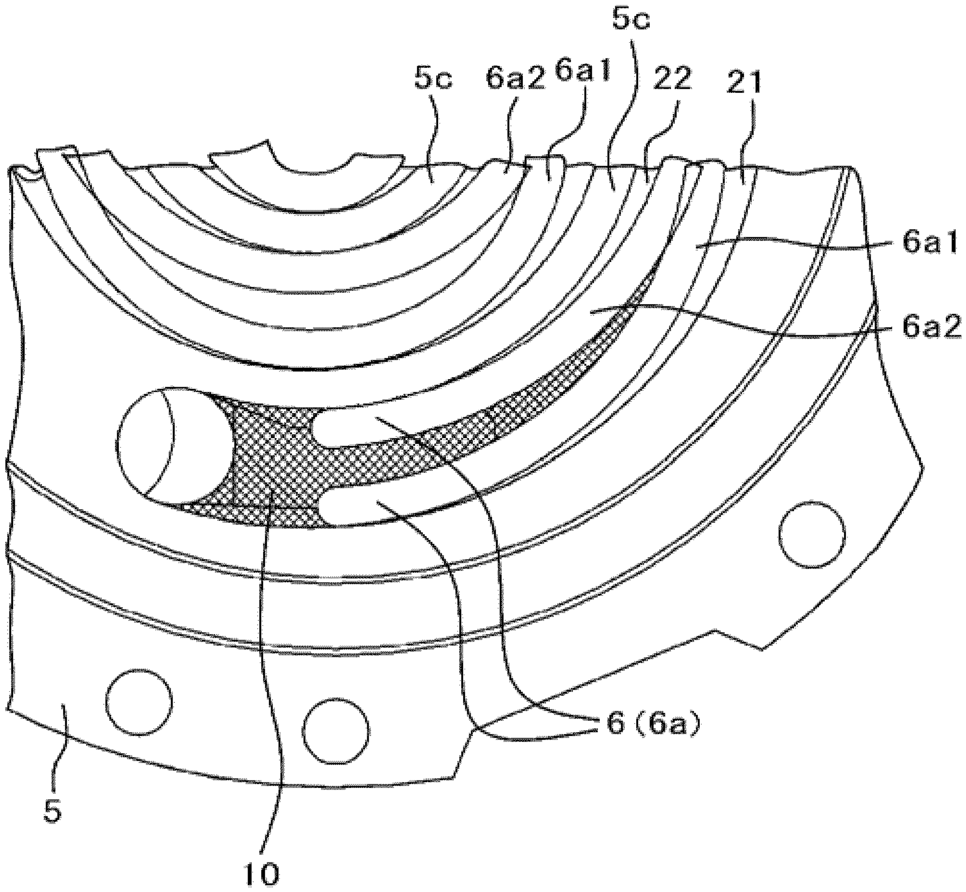


FIG. 3



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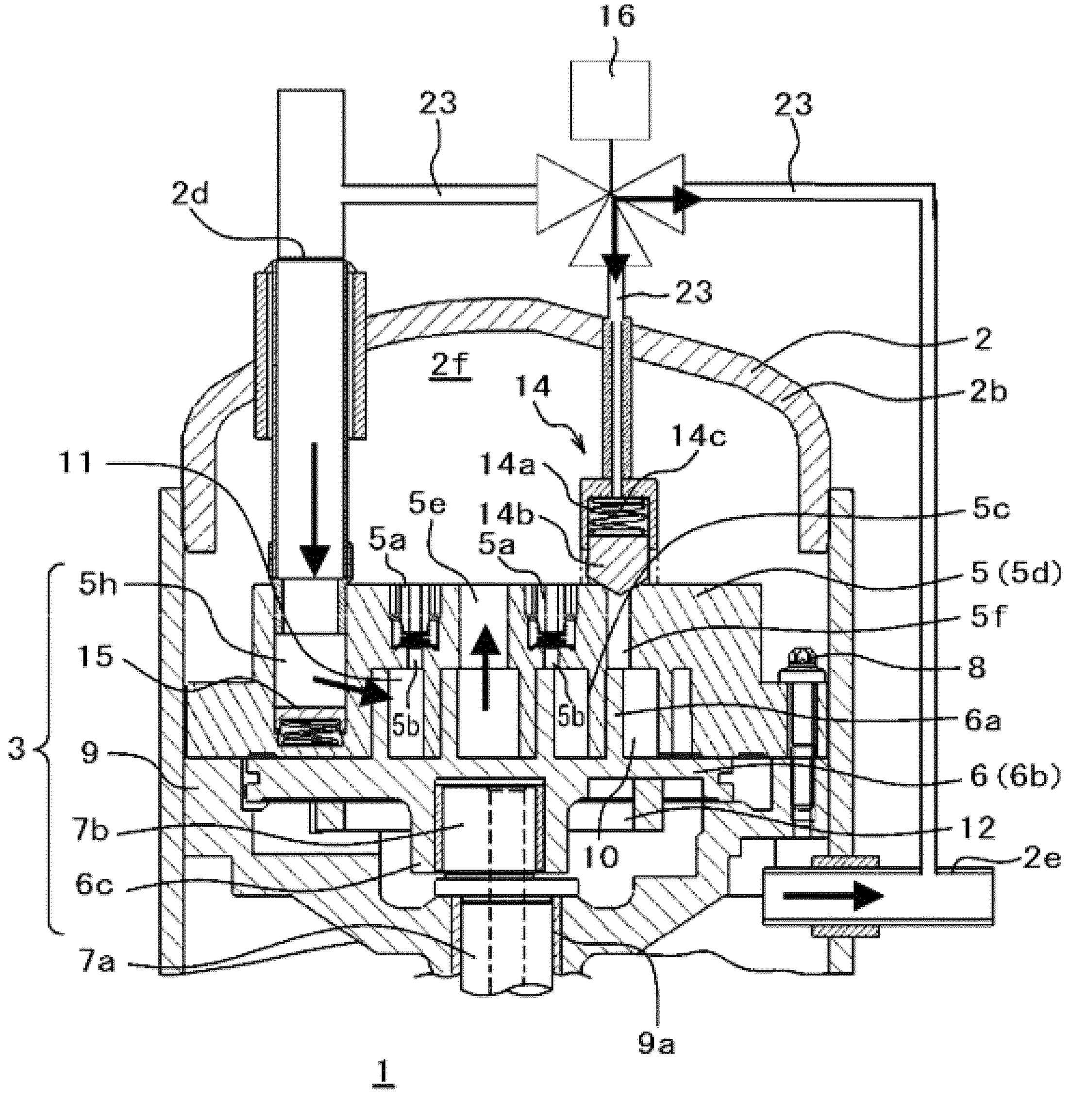
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2b
14c
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14b
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5h
5f
8
15
6a
5b
5b
3
9
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12
7b
10
2e
6c
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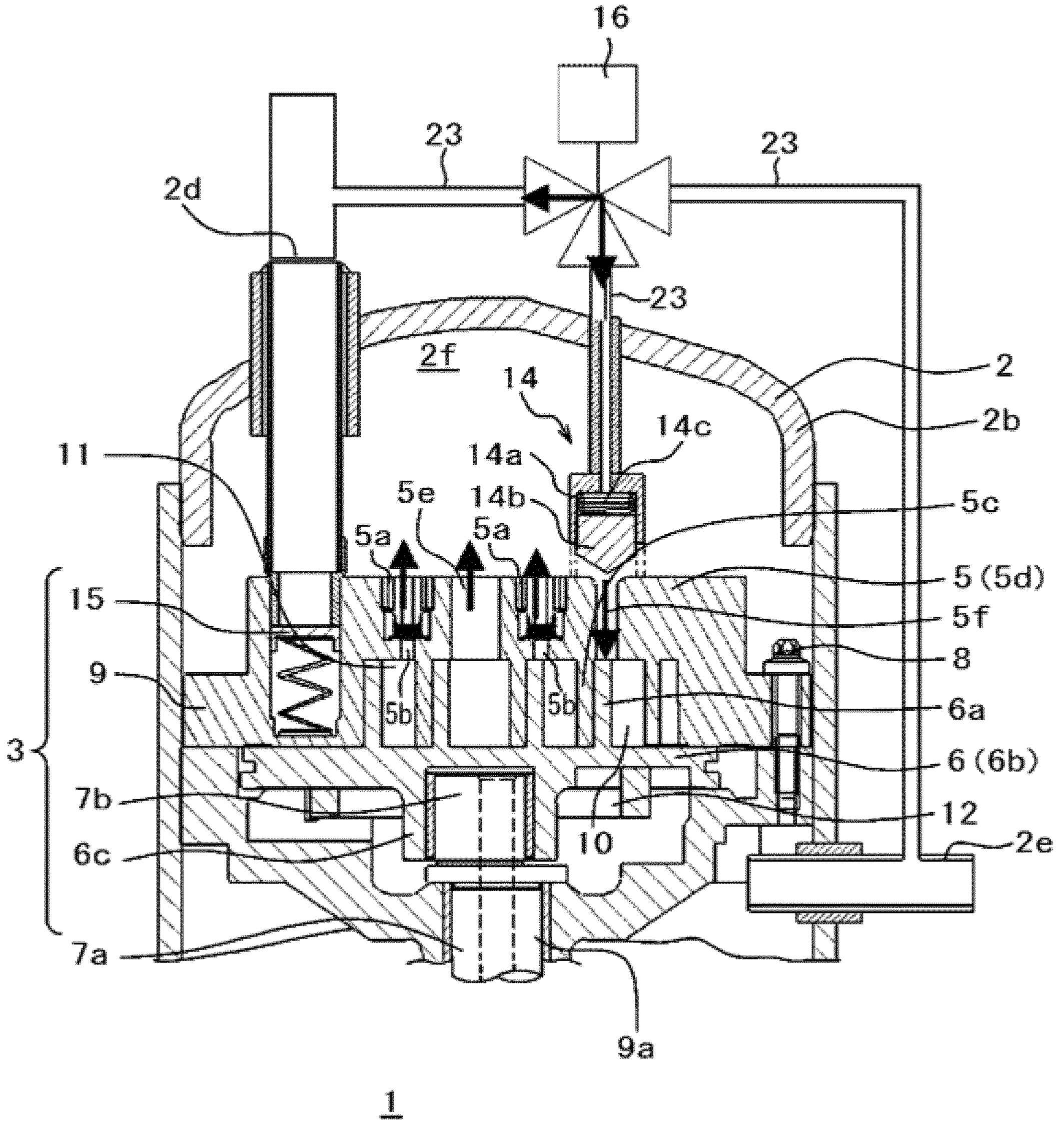
9a
1

FIG.5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23
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14c
11
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14b
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15
5f
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6a
3
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7b
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7a
9a
1

FIG.6

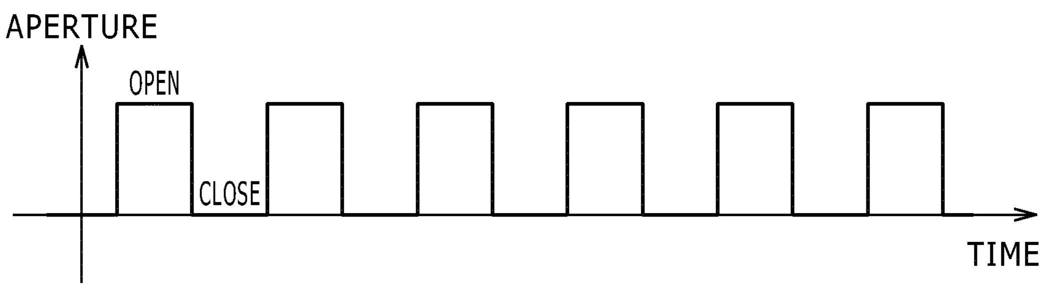
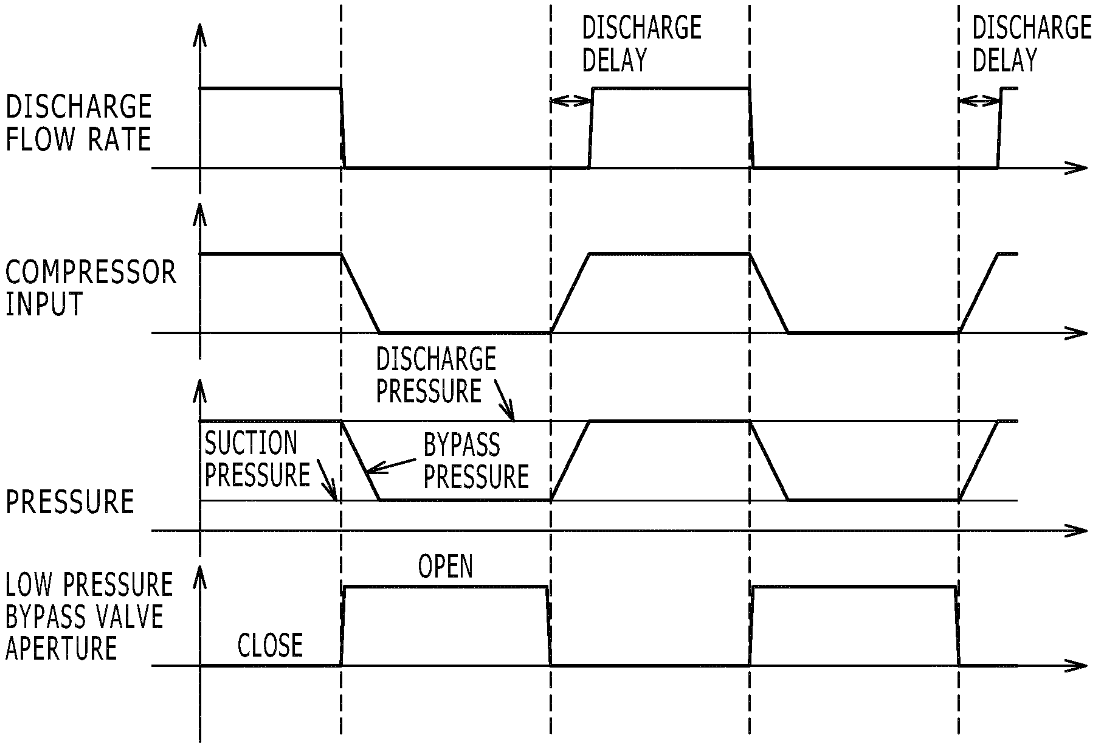

APERTURE
OPEN
CLOSE
TIME

FIG. 7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DISCHARGE DELAY
DISCHARGE DELAY
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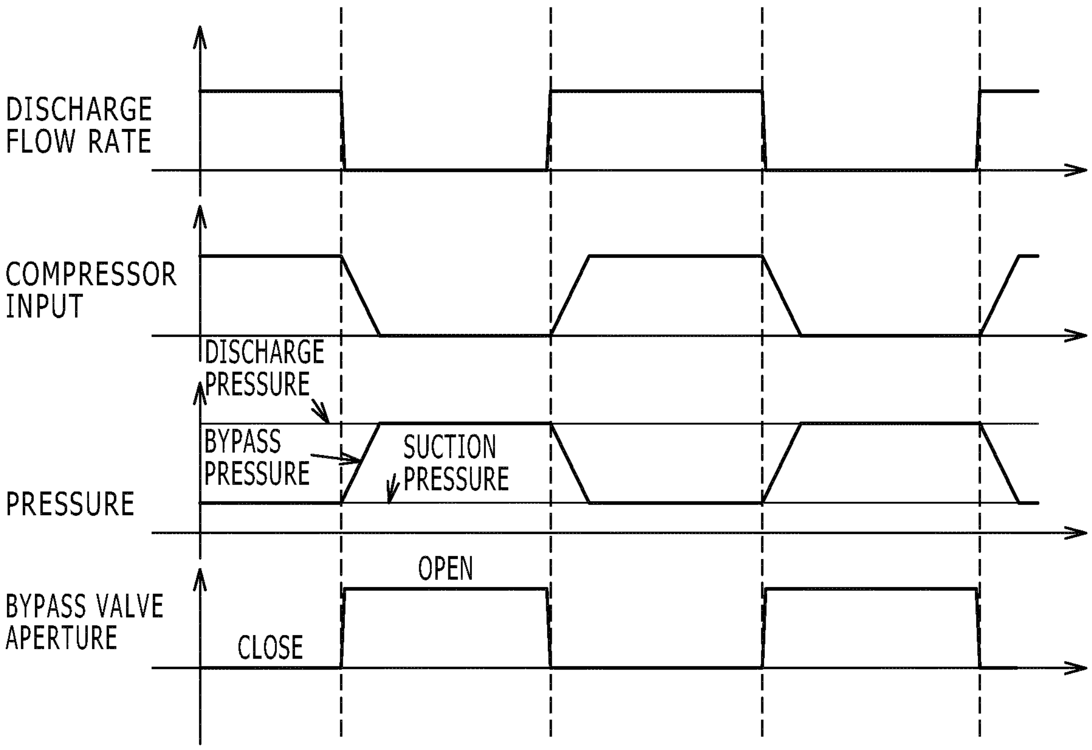
DISCHARGE PRESSURE
SUCTION PRESSURE
BYPASS PRESSURE
PRESSURE
LOW PRESSURE BYPASS VALVE APERTURE
OPEN
CLOSE

FIG. 8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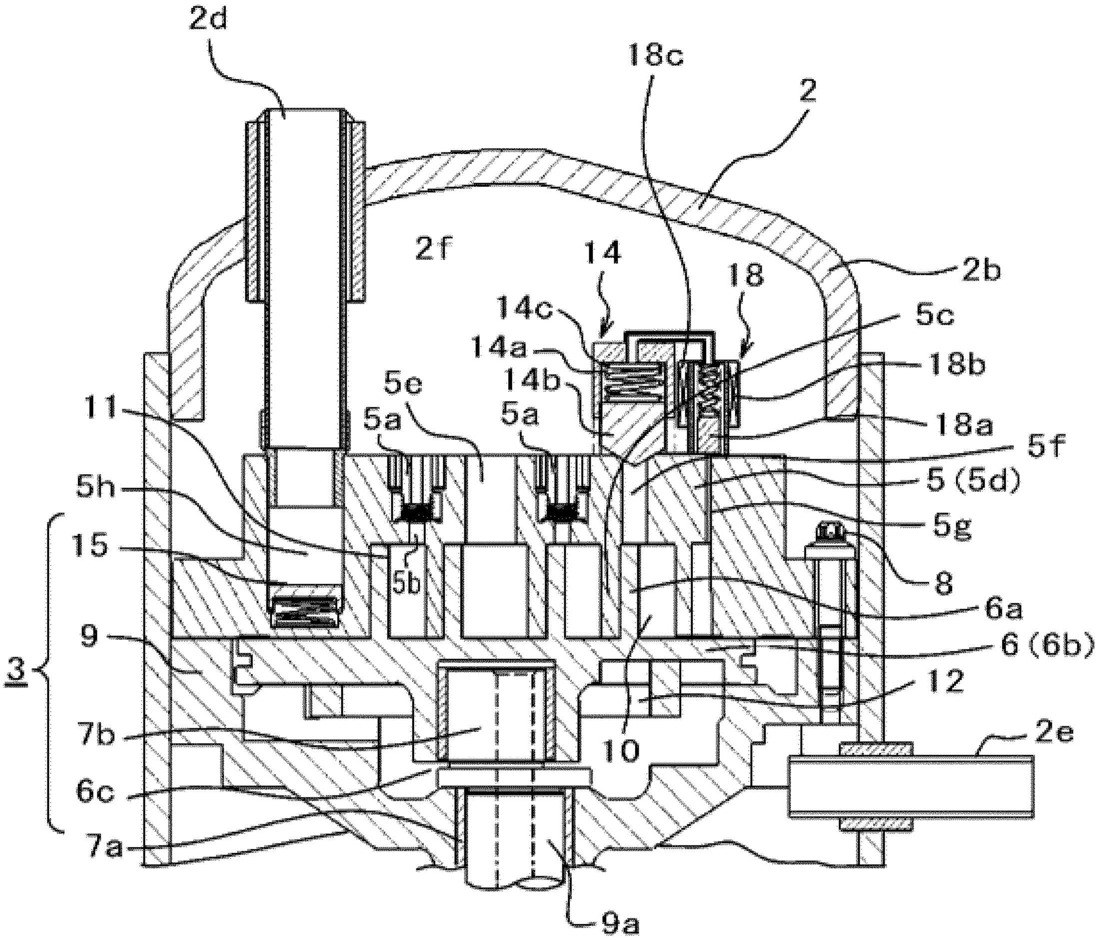
COMPRESSOR INPUT
DISCHARGE PRESSURE
BYPASS PRESSURE
SUCTION PRESSURE
PRESSURE
BYPASS VALVE APERTURE
OPEN
CLOSE

FIG. 9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18
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14a
18b
5e
14b
11
5a
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18a
5f
5h
5 (5d)
5g
15
5b
8
6a
9
6 (6b)
3
12
7b
10
2e
6c
7a
9a

FIG.10

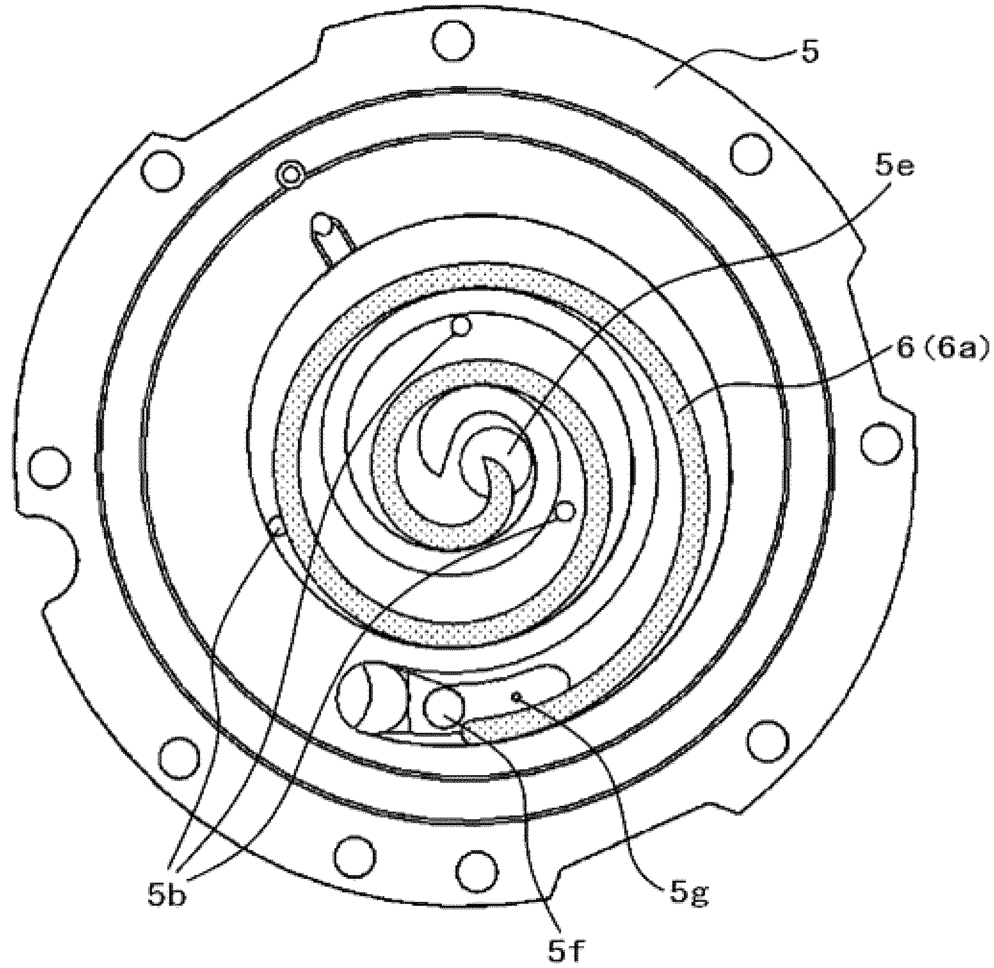
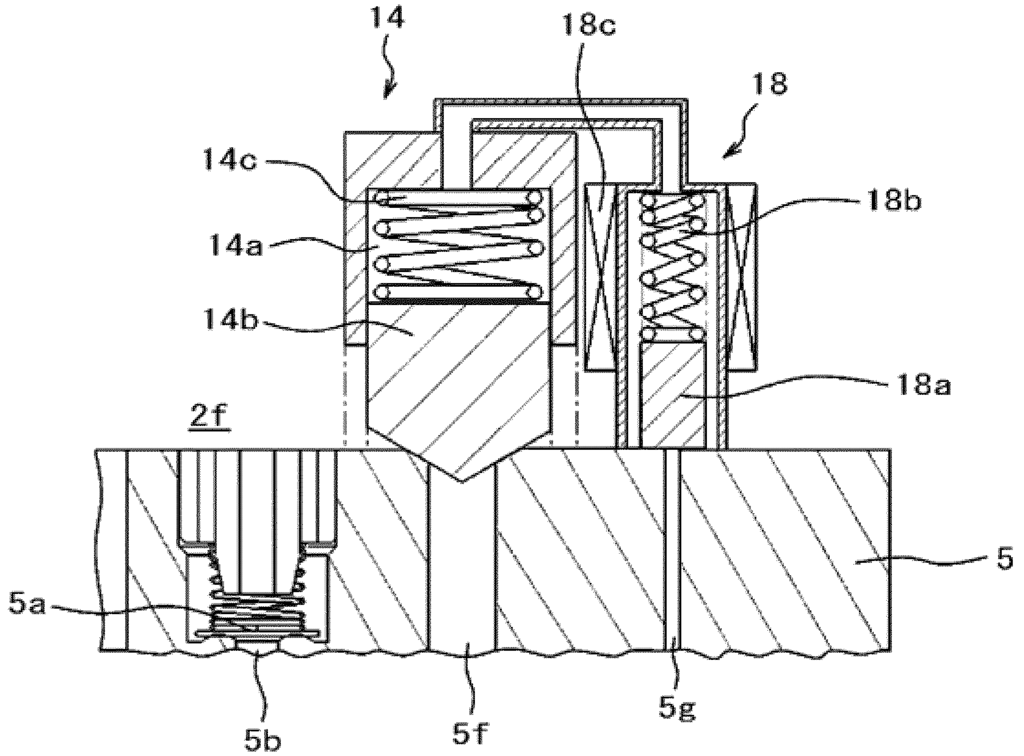


FIG.11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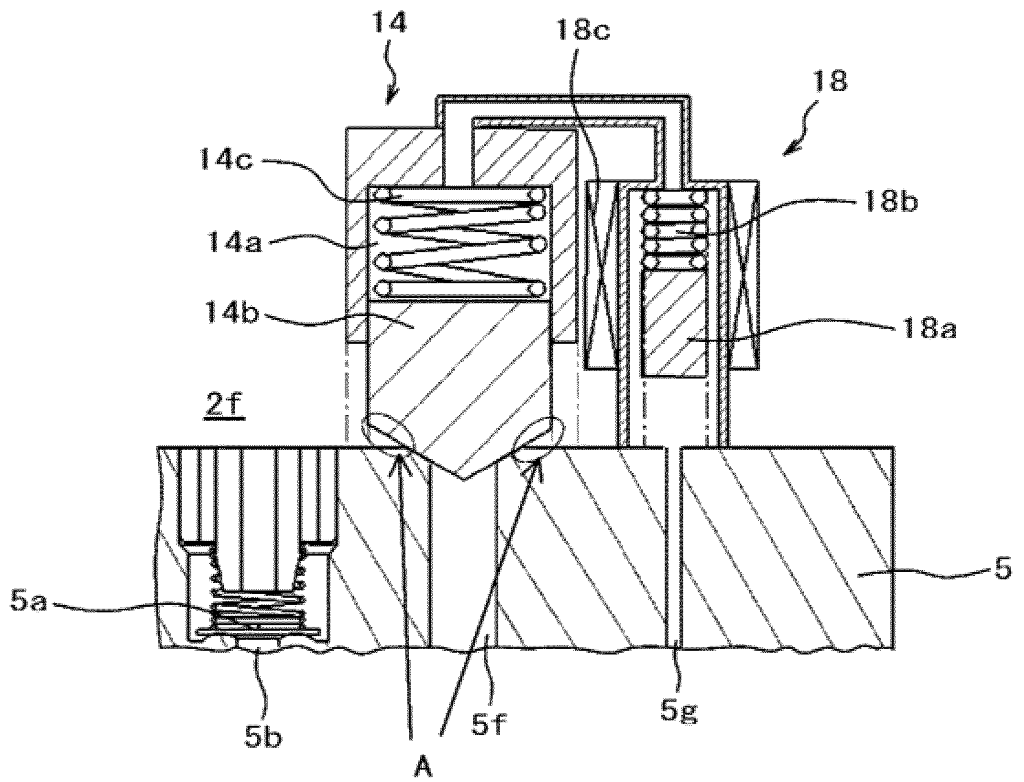
14b
18a
2f
5
5a
5b
5f
5g

FIG.12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18b
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14b
18a
2f
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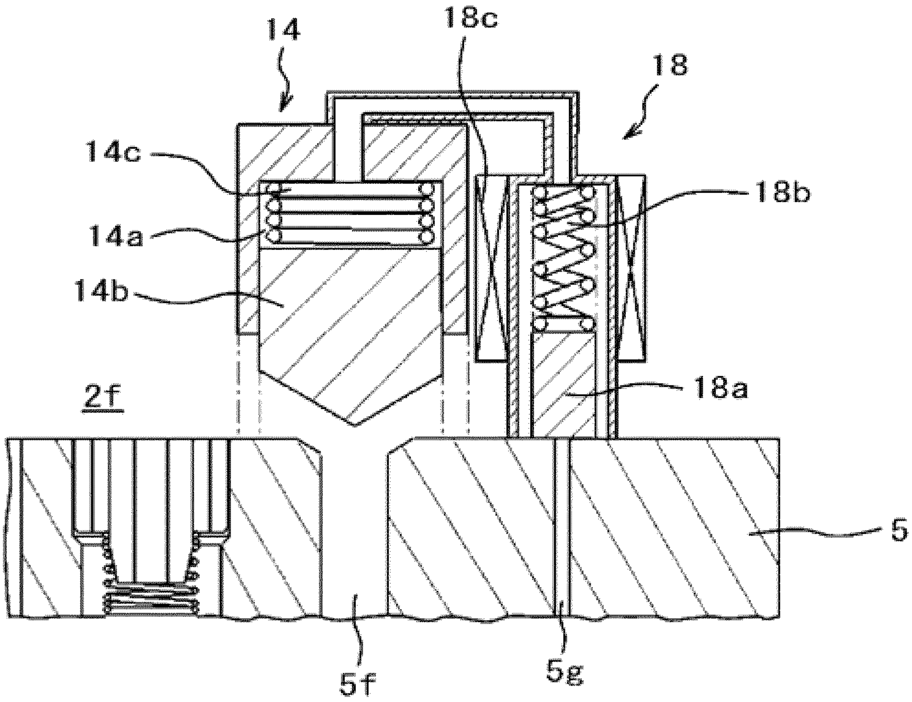
5a
5b
5f
5g
A

FIG.13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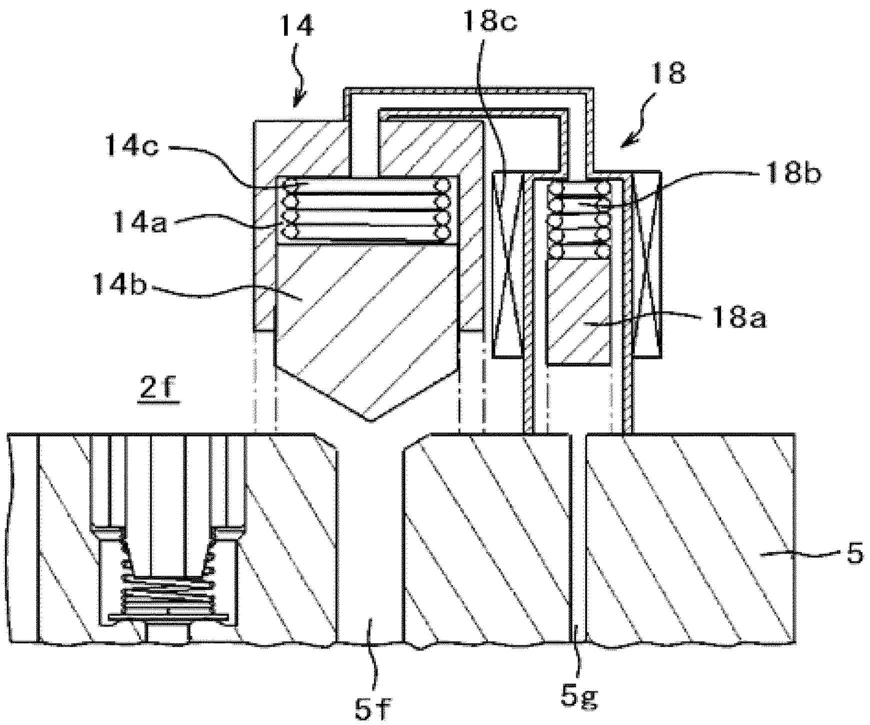
2f
18a
5
5f
5g

FIG.14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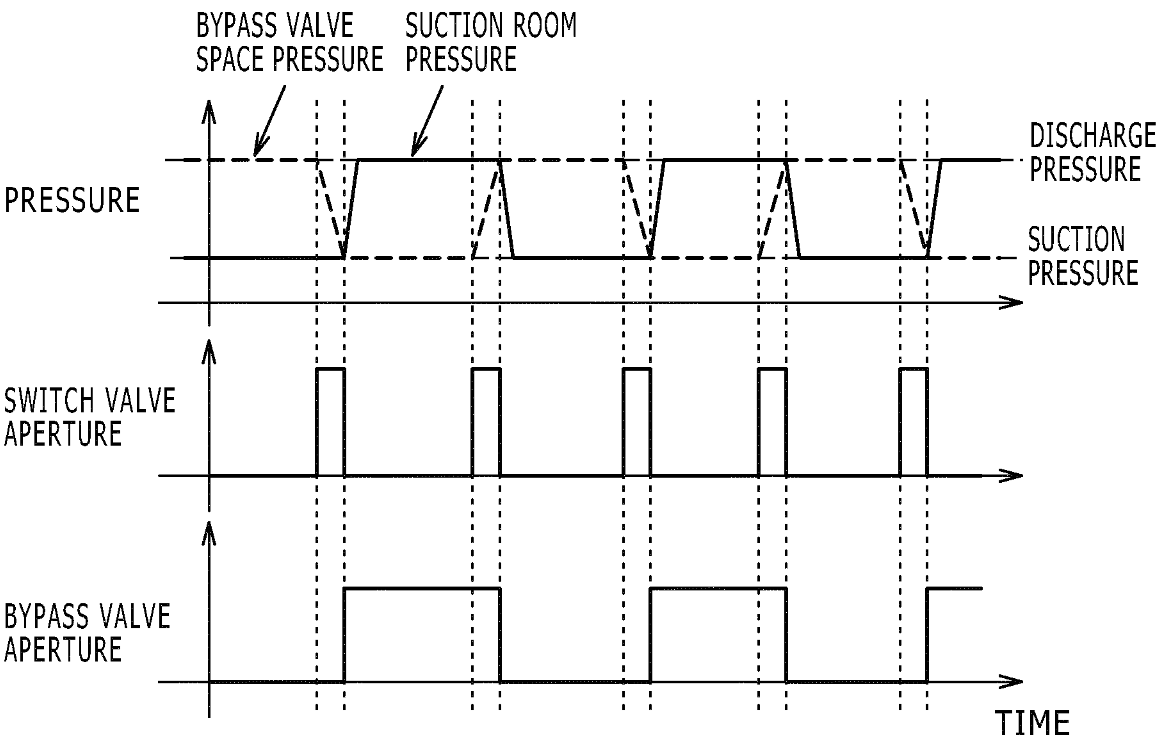
5
5f
5g

FIG.15


BYPASS VALVE
SPACE PRESSURE
SUCTION ROOM
PRESSURE
PRESSURE
DISCHARGE
PRESSURE
SUCTION
PRESSURE
SWITCH VALVE
APERTURE
BYPASS VALVE
APERTURE
TIME

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2011/053841

A. CLASSIFICATION OF SUBJECT MATTER
*F04C18/02*(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)
F04C18/02

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 | 1996-2011 |
| Kokai Jitsuyo Shinan Koho | 1971-2011 | Toroku Jitsuyo Shinan Koho | 1994-2011 |

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 | JP 8-61269 A (Nippon Soken, Inc.), 08 March 1996 (08.03.1996), entire text; all drawings & US 5674058 A | 1-7 |
| A | JP 11-351167 A (Daikin Industries, Ltd.), 21 December 1999 (21.12.1999), claim 1; paragraphs [0031] to [0039]; fig. 1 to 5 & WO 1999/064744 A1 | 1-7 |
| A | JP 2004-143951 A (Tokyo Gas Co., Ltd.), 20 May 2004 (20.05.2004), entire text; all drawings (Family: none) | 1-7 |

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 20 May, 2011 (20.05.11) | 31 May, 2011 (31.05.11) |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Japanese Patent Office | |
| Facsimile No. | Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2011/053841

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 2003-500611 A (LG Electronics Inc.), 07 January 2003 (07.01.2003), entire text; all drawings & WO 2000/073659 A1 | 1-7 |
| A | JP 2006-46114 A (Toshiba Carrier Corp.), 16 February 2006 (16.02.2006), claim 1; fig. 1, 4 (Family: none) | 1-7 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description

- JP 2004143951 A **[0009]**