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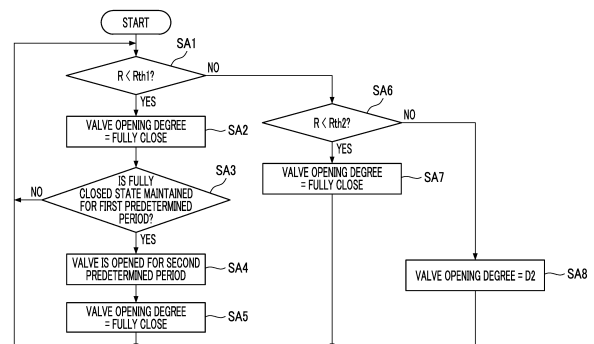
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(54) **SCROLL COMPRESSOR, CONTROL METHOD THEREFOR, AND AIR CONDITIONING APPARATUS**

(57) The purpose of the present invention is to avoid the influence of an increase in oil temperature on peripheral devices while suppressing deterioration of the efficiency of a compressor. This scroll compressor is provided with a back pressure chamber, an oil discharge passage through which oil discharged from the back pressure chamber returns to an oil reservoir in a housing, a valve provided to the oil discharge passage, and a control device which controls the opening degree of the valve. When the compressor rotating speed  $R$  is lower than a first threshold  $R_{th1}$ , the control device controls the flow rate of oil flowing through the oil discharge passage to a preset first flow rate or lower, and temporarily increases the flow rate of oil flowing through the oil discharge passage at a prescribed timing. When the compressor rotating speed  $R$  is equal to or higher than a second threshold  $R_{th2}$ , the control device controls the flow rate of oil flowing through the oil discharge passage to at least a second flow rate which is a value greater than the first flow rate.

FIG. 4



**Description**

## Technical Field

5 **[0001]** The present invention relates to a scroll compressor, a control method therefor, and an air conditioning apparatus.

## Background Art

10 **[0002]** In a closed type scroll compressor, oil accumulated in an oil reservoir in a lower portion of a compressor is pumped by a pump and supplied to a bearing. The pumped oil is returned to the oil reservoir in the lower portion of the compressor through an oil drain passage after passing through a back pressure chamber which is a space provided between an upper bearing and an orbiting scroll.

15 **[0003]** For example, PTL 1 discloses that a solenoid valve is provided in an oil drain passage and an opening degree of the solenoid valve is controlled to control a flow rate of oil discharged from a back pressure chamber. Specifically, PTL 1 discloses that in a case where a rotating speed of an orbiting scroll is equal to or less than a threshold, the solenoid valve is fully closed to increase an amount of oil in the back pressure chamber. In this way, an anti-thrust force can be increased by increasing the amount of oil in the back pressure chamber, and as a result, efficiency of the compressor can be improved.

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## Citation List

## Patent Literature

25 **[0004]** [PTL 1] International Publication No. WO2017/073213

## Summary of Invention

## Technical Problem

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**[0005]** In a case where a solenoid valve is fully closed, oil stagnates in a back pressure chamber, and thus, exhaust heat is not sufficiently performed, a temperature of the oil in the back pressure chamber gradually increases. Accordingly, there is a concern that heat may influence a peripheral device.

35 **[0006]** An object of the present invention is to provide a scroll compressor, a control method therefore, and an air conditioning apparatus capable of avoiding an influence of a temperature increase of oil on a peripheral device while suppressing a decrease in efficiency of a compressor. Solution to Problem

40 **[0007]** According to a first aspect, there is provided a scroll compressor including: a scroll compression mechanism which has a fixed scroll and an orbiting scroll and compresses and discharges a refrigerant between the fixed scroll and the orbiting scroll; a rotary shaft which is a rod-shaped member for orbiting the orbiting scroll; an oil supply passage which is provided inside the rotary shaft along a longitudinal direction and through which oil flowing in from one end of the rotary shaft is discharged from the other end of the rotary shaft; a back pressure chamber which is disposed on the rotary shaft side of the orbiting scroll and into which the oil discharged from the other end of the oil supply passage flows; an oil drain passage through which the oil flowing into the back pressure chamber is discharged; a flow rate adjusting mechanism which changes a flow rate of the oil flowing through the oil drain passage; and a control device which controls the flow rate adjusting mechanism so as to control the flow rate of the oil flowing through the oil drain passage, in which in a case where an orbital speed of the orbiting scroll is less than a preset first threshold, the control device controls the flow rate of the oil flowing through the oil drain passage to be equal to or less than a preset first flow rate and temporarily increases the flow rate of the oil flowing through the oil drain passage at a predetermined timing determined based on a temperature of the oil in the back pressure chamber, and in a case where the orbital speed of the orbiting scroll is the same as the first threshold or equal to or more than a second threshold set to a value larger than the first threshold, the control device controls the flow rate of the oil flowing through the oil drain passage to be equal to or more than a second flow rate which is a value larger than the first flow rate.

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55 **[0008]** According to this configuration, in the case where the orbital speed of the orbiting scroll, that is, a compressor rotating speed is less than the first threshold, the flow rate of the oil flowing out through the oil drain passage from the inside of the back pressure chamber is controlled to be equal or less than the first flow rate. Accordingly, an amount of oil in the back pressure chamber increases, and a pressure in the back pressure chamber increases. Therefore, a force (hereinafter, referred to as an "anti-thrust force") from the orbiting scroll toward the fixed scroll can be increased on a rear surface of the orbiting scroll. The anti-thrust force offsets a portion of a force in a direction away from the fixed scroll

acting on the orbiting scroll, and reduces a loss caused by a friction when the orbiting scroll in the thrust bearing orbits. As a result, it is possible to suppress a decrease in efficiency of the scroll compressor. Meanwhile, if the flow rate of the oil flowing out through the oil drain passage from the inside of the back pressure chamber is controlled to be equal to or less than the first flow rate, the oil easily stagnates in the back pressure chamber, and there is a concern that exhaust heat cannot be sufficiently performed. Even in this case, the flow rate of the oil flowing through the oil drain passage is temporarily increased at the predetermined timing determined in advance based on the temperature of the oil in the back pressure chamber, and thus, it is possible to prevent the temperature from increasing too much. Accordingly, it is possible to avoid an influence of heat on a member around the back pressure chamber.

**[0009]** In the case where the orbital speed of the orbiting scroll is the same as the first threshold or equal to or more than the second threshold set to the value larger than the first threshold, the flow rate of the oil flowing through the oil drain passage is controlled to be equal to or more than a second flow rate which is the value larger than the first flow rate. Accordingly, it is possible to sufficiently perform the exhaust heat while reducing the loss caused by the friction when the orbiting scroll orbits by the anti-thrust force.

**[0010]** For example, the scroll compressor has a housing whose interior is partitioned into a first chamber and a second chamber, and the orbiting scroll and the fixed scroll are disposed in the first chamber within the housing.

**[0011]** In the scroll compressor, the first threshold may be set to be equal to or more than an orbital speed corresponding to a case where the scroll compressor is operated at a capacity of 1/2 of a rated operation and to be equal to or less than an orbital speed corresponding to a case where the scroll compressor is operated at the capacity of the rated operation.

**[0012]** Accordingly, it is possible to effectively suppress the decrease in the efficiency of the scroll compressor.

**[0013]** In the scroll compressor, in a case where the orbital speed of the orbiting scroll is equal to or more than the first threshold and is less than the second threshold set to the value larger than the first threshold, the control device may control the flow rate of the oil flowing through the oil drain passage to be equal to or less than the first flow rate.

**[0014]** According to this configuration, in the case where the orbital speed of the orbiting scroll is equal to or more than the first threshold and is less than the second threshold, the flow rate of the oil flowing an exhaust heat passage is controlled to be equal to or less than the first flow rate. However, a temporary increase of the flow rate at the predetermined timing is not performed. For example, in a region where the orbital speed of the orbiting scroll is equal to or less than the first threshold, an amount of oil which flows into the back pressure chamber through the oil supply path is not sufficient, and thus, for example, exhaust heat in a sliding portion such as a bearing is not promoted. Accordingly, as described above, the flow rate of the oil flowing through the oil drain passage at the predetermined timing is temporarily increased so as to promote the exhaust heat. Meanwhile, in a region in which the orbital speed of the orbiting scroll is equal to or more than the first threshold and less than the second threshold, the rotating speed is in a middle speed region, and an amount of oil sufficient for the exhaust heat of the sliding portion flows into the back pressure chamber through the oil supply passage. For this reason, unlike when the orbital speed of the orbiting scroll is less than or equal to the first threshold, it is not necessary to temporarily increase the flow rate of the oil flowing through the oil drain passage at the predetermined timing.

**[0015]** In this way, in the case where the orbital speed of the orbiting scroll is equal to or more than the first threshold and less than the second threshold, by controlling the flow rate of the oil flowing through the exhaust heat passage to be equal to or less than the first flow rate, it is possible to generate a relatively large anti-thrust force, and it is possible to suppress the decrease in the efficiency of the scroll compressor. Moreover, it is possible to promote the exhaust heat of the sliding portion such as the bearing, and it is possible to avoid an influence of heat on a member around the back pressure chamber.

**[0016]** In the scroll compressor, a timing at which a temperature of the oil in the back pressure chamber reaches a preset upper limit temperature may be estimated or tested in advance, and the predetermined timing may be determined in advance based on a result of the estimation or test.

**[0017]** For example, a temperature increase in the back pressure chamber when various conditions (for example, a temperature of a fluid sucked into the compressor or the like) are changed is simulated or tested in real machine in advance, and the predetermined timing is determined based on an elapsed time until the temperature of the oil in the back pressure chamber reaches the preset upper limit temperature. In this way, by performing the simulation or the like in advance and setting the predetermined timing in advance, it is not necessary to provide a temperature sensor or the like, and it is possible to easily alleviate an excessive temperature increase of the oil in the back pressure chamber.

**[0018]** In the scroll compressor, the scroll compressor may further include a temperature estimation unit which estimates the temperature of the oil in the back pressure chamber, in which in a case where the temperature of the oil estimated by the temperature estimation unit is equal to or more than a preset upper limit temperature, the control device may determine that the predetermined timing reaches and temporarily increase the flow rate of the oil flowing through the oil drain passage.

**[0019]** According to this configuration, in the case where the temperature of the oil estimated by the temperature estimation unit is equal to or more than the preset upper limit temperature, the control device determines that the

predetermined timing reaches and temporarily increases the flow rate of the oil flowing through the oil drain passage. Therefore, it is possible to easily prevent the temperature of the oil in the back pressure chamber from excessively increasing.

**[0020]** According to a second aspect of the present invention, there is provided an air conditioning apparatus including: a condenser which condenses a refrigerant; an evaporator which evaporates the refrigerant condensed by the condenser; and the scroll compressor which compresses the refrigerant evaporated by the evaporator.

**[0021]** According to a third aspect, there is provided a control method of a scroll compressor including a scroll compression mechanism which includes a housing whose interior is partitioned into a first chamber and a second chamber, and a fixed scroll and an orbiting scroll disposed in the first chamber, compresses a refrigerant between the fixed scroll and the orbiting scroll, and discharges the compressed refrigerant to the second chamber, a rotary shaft which is a rod-shaped member for orbiting the orbiting scroll, an oil supply passage which is provided inside the rotary shaft along a longitudinal direction and through which oil flowing in from one end of the rotary shaft is discharged from the other end of the rotary shaft, a back pressure chamber which is disposed on the rotary shaft side of the orbiting scroll and into which the oil discharged from the other end of the oil supply passage flows, and an oil drain passage through which the oil flowing into the back pressure chamber is discharged, the method including: in a case where an orbital speed of the orbiting scroll is less than a preset first threshold, controlling the flow rate of the oil flowing through the oil drain passage to be equal to or less than a preset first flow rate and temporarily increasing the flow rate of the oil flowing through the oil drain passage at a predetermined timing; and in a case where the orbital speed of the orbiting scroll is the same as the first threshold or equal to or more than a second threshold set to a value larger than the first threshold, controlling the flow rate of the oil flowing through the oil drain passage to be equal to or more than a second flow rate which is a value larger than the first flow rate. Advantageous Effects of Invention

**[0022]** It is possible to avoid an influence of a temperature increase of oil on a peripheral device while suppressing a decrease in efficiency of a compressor.

#### Brief Description of Drawings

#### **[0023]**

Fig. 1 is a view showing a schematic configuration of a refrigerant circuit of an air conditioning apparatus according to an embodiment of the present invention.

Fig. 2 is an overall sectional view of a scroll compressor according to the embodiment of the present invention.

Fig. 3 is an enlarged sectional view showing peripheries of a back pressure chamber and an oil drain passage in an enlarged manner in the overall sectional view of the scroll compressor shown in Fig. 2.

Fig. 4 is a flowchart showing a control procedure of a valve according to the embodiment of the present invention.

#### Description of Embodiments

**[0024]** Hereinafter, a scroll compressor, a control method therefor, and an air conditioning apparatus according to an embodiment of the present invention will be described with reference to the drawings. In the embodiment described below, a case where the scroll compressor is applied to an air conditioning apparatus is described as an example. However, the scroll compressor of the present invention is not limited to the air conditioning apparatus, and may be appropriately applied to other devices.

**[0025]** Fig. 1 is a view showing a schematic configuration of a refrigerant circuit of an air conditioning apparatus 10 according to the embodiment of the present invention. As shown in Fig. 1, the air conditioning apparatus 10 has a refrigerant circuit which is configured by sequentially connecting a scroll compressor 1, a four-way switching valve 2, an outdoor heat exchanger 4, an electronic expansion valve 6, and an indoor heat exchanger 8 to each other by a refrigerant pipe and can perform an air-conditioning operation.

**[0026]** The scroll compressor 1 can control a drive frequency of a motor by an inverter control, sucks a low pressure and temperature refrigerant gas from a low-pressure side of the refrigerant circuit, compresses the low pressure and temperature refrigerant gas such that the low pressure and temperature refrigerant gas is a high temperature and pressure refrigerant gas, and discharge the high temperature and pressure refrigerant gas to a high-pressure side.

**[0027]** The four-way switch valve 2 is switched to circulate the high temperature and pressure refrigerant gas discharged from the scroll compressor 1 to the outdoor heat exchanger 4 side during a cooling operation and circulate the high temperature and pressure refrigerant gas to the indoor heat exchanger 8 side during a heating operation.

**[0028]** The outdoor heat exchanger 4 functions as a condenser which performs heat exchange between the high temperature and pressure refrigerant gas supplied from the scroll compressor 1 and the outside air during the cooling operation so as to condense and liquefy the refrigerant, functions as an evaporator which performs heat exchange between a low temperature and pressure two-phase refrigerant supplied via the electronic expansion valve 6 and the

outside air during the heating operation so as to evaporate the refrigerant, and includes an outdoor fan (not shown) for blowing the outside air.

**[0029]** The electronic expansion valve 6 adiabatically expands the high pressure liquid refrigerant condensed by the outdoor heat exchanger 4 or the indoor heat exchanger 8 into a low temperature and pressure gas-liquid two-phase refrigerant and for example, an electric expansion valve driven by a pulse motor is used as the electronic expansion valve 6.

**[0030]** The indoor heat exchanger 8 functions as an evaporator which performs heat exchange between the low temperature and pressure gas-liquid two-phase refrigerant introduced via the electronic expansion valve 6 and indoor air to be air-conditioned during the cooling operation and evaporates the refrigerant so as to cool the indoor air, functions as a condenser which performs heat exchange between the high temperature and pressure refrigerant gas supplied from the scroll compressor 1 and the indoor air to be air-conditioned during the heating operation and condenses the refrigerant so as to heat the indoor air, and includes an indoor fan (not shown) for circulating the indoor air.

**[0031]** In the air conditioning apparatus 10, during the cooling operation, the high temperature and pressure refrigerant gas discharged from the scroll compressor 1 is introduced into the outdoor heat exchanger 4 by the four-way switching valve 2 and is heat-exchanged with the outside air so as to be condensed and liquefied. This high pressure liquid refrigerant is adiabatically expanded by the electronic expansion valve 6 to be the low temperature and pressure gas-liquid two-phase refrigerant and is introduced into the indoor heat exchanger 8. In the indoor heat exchanger 8, the low temperature and pressure gas-liquid two-phase refrigerant is heat-exchanged with the indoor air, absorbs heat so as to be evaporated, becomes a low temperature and pressure refrigerant gas, and is sucked to the scroll compressor 1. Moreover, the indoor air which is cooled by the evaporation of the refrigerant in the indoor heat exchanger 8 is blown into the room via the indoor fan, and thus, the cooling operation is performed.

**[0032]** Meanwhile, during the heating operation, the high temperature and pressure refrigerant gas discharged from the scroll compressor 1 is introduced to the indoor heat exchanger 8 by the four-way switching valve 2, is heat-exchanged with the indoor air, and is condensed and liquefied. In this case, the indoor air is heated by the discharged heat. The high pressure liquid refrigerant which is condensed and liquefied by the indoor heat exchanger 8 is adiabatically expanded by the electronic expansion valve 6 so as to be the low temperature and pressure gas-liquid two-phase refrigerant and is introduced into the outdoor heat exchanger 4. In the outdoor exchanger 4, the low temperature and pressure gas-liquid two-phase refrigerant is heat-exchanged with the outside air, absorbs heat from the outside air to be evaporated, and is sucked into the scroll compressor 1 as a low temperature and pressure refrigerant gas. In addition, the indoor air which is overheated by heat discharged from the refrigerant in the indoor heat exchanger 8 is blown into the room via the indoor fan, and thus, the heating operation is performed.

**[0033]** Next, the scroll compressor 1 according to the embodiment of the present invention will be described with reference to the drawings. Fig. 2 is an overall sectional view of the scroll compressor 1 according to the embodiment of the present invention, and Fig. 3 is an enlarged sectional view showing peripheries of a back pressure chamber and an oil drain passage in an enlarged manner in the overall sectional view of the scroll compressor shown in Fig. 2.

**[0034]** As shown in Fig. 2, the scroll compressor 1 includes a motor 5 which is a drive device of the scroll compressor 1 and a scroll compression mechanism 7 which is driven by the motor 5 inside a housing 3. A frequency of the motor 5 is controlled by an inverter (not shown). A control of the inverter may be performed by a control device 53 described later, or a dedicated control device for controlling the inverter may be provided. The inverter may be controlled by a control device of the air conditioning apparatus 10.

**[0035]** The housing 3 includes a tubular housing main body 3a which vertically extends, a bottom portion 3b which closes a lower end of the housing main body 3a, and a cover portion 3c which closes an upper end of the housing main body 3a. The housing 3 is a pressure container whose entirety is sealed. A suction pipe 9 through which the refrigerant is introduced into the housing 3 is provided on a side portion of the housing main body 3a.

**[0036]** A discharge pipe 11 through which the refrigerant compressed by the scroll compression mechanism 7 is discharged is provided on the upper portion of the cover portion 3c. In the housing 3, a discharge cover 13 is provided between the housing main body 3a and the cover portion 3c, and the interior space of the housing 3 is divided into a low-pressure chamber 3A which is a first chamber positioned below the discharge cover 13 which is a partitioning member and a high-pressure chamber 3B which is a second chamber positioned above the discharge cover 13. Even in a case where the discharge cover 13 is not provided in the housing 3, a fixed scroll 33 and an upper bearing 21 function as the partitioning member. The discharge cover 13 includes an opening hole 13a through which the low-pressure chamber 3A and the high-pressure chamber 3B communicate with each other, and a discharge reed valve 13b which opens or closes the opening hole 13a. An oil reservoir 3bt in which oil is stored is formed on a bottom in the housing 3.

**[0037]** The motor 5 includes a stator 15 and a rotor 17. The stator 15 is fixed to an inner wall surface at an approximately intermediate portion in a vertical direction of the housing main body 3a. The rotor 17 is rotatably provided to the stator 15. A rotary shaft 19 is vertically disposed with respect to the rotor 17 in the longitudinal direction. Power is supplied to the motor 5 from the outside of the housing 3 to rotate the rotor 17, and thus, the rotor 17 and the rotary shaft 19 are rotated.

**[0038]** The rotary shaft 19 is a rod-shaped member which causes an orbiting scroll 35 of the scroll compression

mechanism 7 to orbit. The rotary shaft 19 is provided such that end portions protrude upward and downward from the rotor 17, and an upper end portion of the rotary shaft 19 is rotatably supported by an upper bearing 21 and a lower end portion thereof is rotatably supported by a lower bearing 23 with respect to the housing main body 3a about an axis CE extending in the vertical direction. The axis CE is a longitudinal direction of the rotary shaft 19 which is a rod-shaped member.

**[0039]** In the rotary shaft 19, an eccentric pin 25 which protrudes upward along an eccentricity LE eccentric to the axis CE is formed on an upper end of the rotary shaft 19. The scroll compression mechanism 7 is connected to the upper end of the rotary shaft 19 having the eccentric pin 25. The rotary shaft 19 and the eccentric pin 25 has an oil supply passage 27 which extends up and down, that is, in the longitudinal direction of the rotary shaft 19 in the insides of the rotary shaft 19 and the eccentric pin 25. In the present embodiment, the oil supply passage 27 penetrates the rotary shaft 19 from one end of the rotary shaft 19 toward the other end thereof. The oil supply passage 27 and the rotary shaft 19 are disposed such that lower ends thereof reach the oil reservoir 3bt, and an oil supply pump 29 is provided on the lower end of the rotary shaft 19. The oil supply pump 29 is driven by the rotary shaft 19. The oil supply pump 29 feeds the lubricant oil stored in the oil reservoir 3bt to the oil supply passage 27 of the rotary shaft 19 according to the rotation of the rotary shaft 19. The oil fed by the oil supply pump 29 passes through the oil supply passage 27 and flows out from an outlet 27H which is provided on the end portion on the scroll compression mechanism 7 side.

**[0040]** In the present embodiment, the oil supply pump 29 increases a discharge flow rate of the oil according to an increase in a rotational speed of the rotary shaft 19, that is, a rotational speed of the motor 5. For example, the oil supply pump 29 is a positive-displacement pump and a centrifugal pump. However, the present invention is not limited to this. Preferably, by using the positive-displacement pump as the oil supply pump 29, it is possible to relatively easily increase the pressure of the oil in a back pressure chamber 50 even in a case where an oil drain passage 51 is narrowed.

**[0041]** The upper end portion of the rotary shaft 19 penetrates the upper bearing 21, and thus, the upper bearing rotatably supports the rotary shaft 19. In the upper bearing 21, a recessed portion 21a is formed on an upper surface of the upper bearing 21 to surround the upper end portion of the rotary shaft 19 penetrating the upper bearing 21. A slide bush 37 described later is accommodated in the recessed portion 21a, and the oil fed via the oil supply passage 27 by the oil supply pump 29 is stored in the recessed portion 21a.

**[0042]** In the upper bearing 21, a notch 21b is formed on a portion of an outer periphery to have a gap between an inner wall surface of the housing main body 3a and the upper bearing 21. A cover plate 31 is provided below the notch 21b of the upper bearing 21. The cover plate 31 is provided to extend in the vertical direction. The cover plate 31 is formed such that both side ends are curved toward the inner wall surface of the housing main body 3a so as to cover a periphery of the notch 21b, and is formed such that a lower end of the cover plate 31 is gradually bent toward the inner wall surface of the housing main body 3a.

**[0043]** In the interior space of the housing 3, the scroll compression mechanism 7 is disposed above the upper bearing 21 in the low-pressure chamber 3A below the discharge cover 13, and includes the fixed scroll 33, the orbiting scroll 35, and the slide bush 37.

**[0044]** In the fixed scroll 33, a spiral fixed wrap 33b is formed on an inner surface (lower surface in Fig. 1) of the fixed end plate 33a fixed to the interior space of the housing 3. A discharge hole 33c is formed at the center portion of the fixed end plate 33a.

**[0045]** In the orbiting scroll 35, a spiral movable wrap 35b is formed on an inner surface (upper surface in Fig. 1) of a movable end plate 35a facing the inner surface of the fixed end plate 33a in the fixed scroll 33. In addition, the movable wrap 35b of the orbiting scroll 35 and the fixed wrap 33b of the fixed scroll 33 mesh with each other with their phases shifted from each other, and thus, a compression chamber which is partitioned by the fixed end plate 33a, the movable end plate 35a, the fixed wrap 33b, and the movable wrap 35b is formed.

**[0046]** In the orbiting scroll 35, a cylindrical boss 35c to which the eccentric pin 25 of the rotary shaft 19 is connected and an eccentric rotation of the eccentric pin 25 is transmitted is formed on the outer surface (lower surface in Fig. 1) of the movable end plate 35a. The boss 35c is disposed on the outlet 27H side of the oil supply passage 27 included in the rotary shaft 19. In the present embodiment, the outlet 27H of the oil supply passage 27 faces the movable end plate 35a of the orbiting scroll 35. The orbiting scroll 35 orbits while being prevented from rotating on the basis of the eccentric rotation of the eccentric pin 25 by a rotation prevention mechanism 39 such as an Oldham link disposed between the outer surface of the movable end plate 35a and the upper bearing 21.

**[0047]** The slide bush 37 is accommodated in the recessed portion 21a of the above-described upper bearing 21, is interposed between the eccentric pin 25 of the rotary shaft 19 and the boss 35c of the orbiting scroll 35, and transmits the rotation of the eccentric pin 25 to the orbiting scroll 35. The slide bush 37 is provided to be slidable in a radial direction of the eccentric pin 25 to maintain meshing between the movable wrap 35b of the orbiting scroll 35 and the fixed wrap 33b of the fixed scroll 33.

**[0048]** In the present embodiment, a space formed by a rear surface 35ab of the orbiting scroll 35, that is, a surface facing the upper bearing 21 of the movable end plate 35a, the recessed portion 21a, and the upper bearing 21 is referred to as a back pressure chamber 50. The back pressure chamber 50 is formed between the orbiting scroll 35 and the

upper bearing 21 which rotatably supports the rotary shaft 19 on the orbiting scroll 35 side.

**[0049]** The back pressure chamber 50 is connected to the oil drain passage 51. The oil drain passage 51 is provided outside the housing 3, one end of the oil drain passage 51 penetrates the housing 3 and is connected to the back pressure chamber 50, and the other end of the oil drain passage 51 penetrates the housing 3 and is connected to the oil reservoir 3bt provided on the bottom in the housing 3. That is, the oil drain passage 51 is an external pipe through which the back pressure chamber 50 and the oil reservoir 3bt communicate with each other. A flow rate adjusting mechanism which adjusts a flow rate of the oil flowing through the oil drain passage 51 is provided in the oil drain passage 51. For example, the flow rate adjusting mechanism is a valve 52 which can adjust a valve opening degree. For example, the valve 52 has a mechanism which changes an area of a portion through which the oil passes. As a specific example of the valve 52, there is an electromagnetic on-off valve or an electromagnetic flow rate control valve. The opening degree of the valve 52 is controlled by the control device 53. For example, the control device 53 is a computer having a processor and a memory. The control device 53 may be a control device (not shown) of the air conditioning apparatus 10 on which the scroll compressor 1 is mounted, or may be a dedicated device for controlling an operation of the valve 52.

**[0050]** In Figs. 2 and 3, the case where one oil drain passage 51 is provided is described. However, the number of oil drain passages 51 is not limited, and a plurality of oil drain passages 51 may be provided. The oil drain passage 51 need not necessarily be provided outside the housing 3 and may be provided inside the housing 3, for example. In a case where a plurality of oil drain passages 51 are provided, some oil drain passage 51 may be provided outside the housing 3 and the rest may be provided inside the housing 3.

**[0051]** In the scroll compressor 1 having the above-described configuration, the refrigerant is introduced to the low-pressure chamber 3A in the housing 3 via the suction pipe 9. The refrigerant introduced into the low-pressure chamber 3A is compressed while being sucked into the compression chamber between the fixed scroll 33 and the orbiting scroll 35 according to the orbiting of the orbiting scroll 35. The compressed high-pressure refrigerant is discharged from the discharge hole 33c of the fixed scroll 33 to the outer surface side of the fixed end plate 33a, opens the discharge reed valve 13b of the discharge cover 13 by the pressure of the refrigerant, flows into the high-pressure chamber 3B from the opening hole 13a, and is discharged to the outside of the housing 3 via the discharge pipe 11.

**[0052]** During the operation, a pressure in the low-pressure chamber 3A of the scroll compressor 1 is the same as a suction pressure which is a pressure by which the scroll compression mechanism 7 sucks the refrigerant. Accordingly, the orbiting scroll 35 of the scroll compression mechanism 7 receives a force (hereinafter, referred to as a "thrust force") in a direction away from the fixed scroll 33 by the refrigerant during compression of the refrigerant. This force is supported by a thrust bearing 40 installed on the upper surface of the upper bearing 21. The thrust force acts on the thrust bearing 40, and thus, when the orbiting scroll 35 orbits, a loss (hereinafter, referred to as a "thrust loss") is caused by a friction between the rear surface 35ab of the orbiting scroll 35 and the thrust bearing 40.

**[0053]** The thrust force can be reduced by the oil which has flowed into the back pressure chamber 50. That is, in the present embodiment, the oil stored in the oil reservoir 3bt is sucked by the oil supply pump 29, is introduced to the oil supply passage 27, and flows from the outlet 27H of the oil supply passage 27 into the back pressure chamber 50. The oil which has flowed into the back pressure chamber 50 flows to the oil drain passage 51 and is returned to the oil reservoir 3bt on the lower end of the housing main body 3a through the oil drain passage 51. In this case, by controlling the opening degree of the valve 52 provided in the oil drain passage 51, it is possible to adjust the flow rate of the oil flowing out from the back pressure chamber 50, and it is possible to adjust an amount of oil in the back pressure chamber 50.

**[0054]** As the amount of oil in the back pressure chamber 50 increases, the pressure of the oil in the back pressure chamber 50 increases, and it is possible to increase an anti-thrust force acting on the orbiting scroll 35 in a direction opposite to the thrust force. Accordingly, it is possible to reduce the thrust force acting on the orbiting scroll 35, and thus, it is possible to reduce the thrust loss. Therefore, it is possible to suppress a decrease in efficiency of the scroll compressor 1.

**[0055]** Next, the control of the valve 52 provided in the scroll compressor according to the embodiment of the present invention will be described with reference to Fig. 4. Fig. 4 is a diagram showing a flowchart of valve control processing performed by the control device 53.

**[0056]** First, the control device 53 determines whether or not a rotating speed of the orbiting scroll 35, that is, a rotating speed (hereinafter, referred to as a "compressor rotating speed") R of the scroll compressor 1 is less than a preset first threshold Rth1 (SA1). In a case where the compressor rotating speed R is less than the first threshold Rth1 (hereinafter, referred to as a "first low speed mode") ("YES" in SA 1), the opening degree of the valve 52 is set to a preset first opening degree (SA 2). In the present embodiment, the first opening degree is set to zero, that is, a fully closed state.

**[0057]** Subsequently, it is determined whether the fully closed state of the valve 52 is maintained for a first predetermined period (SA3). As a result, if the fully closed state is not maintained for the first predetermined period ("NO" in SA3), the process returns to Step SA1. Meanwhile, in a case where the fully closed state is maintained for the first predetermined period ("YES" in SA3), the valve 52 is temporarily opened. For example, the valve 52 is controlled to a predetermined opening degree larger than the first opening degree, and this state is maintained for a preset second predetermined

period (SA4). If the second predetermined period elapses after the valve opening degree is controlled to the predetermined opening degree, the valve 52 is set to the fully closed state again (SA5), and the process returns to Step SA1. The opening degree of the valve in Step SA4 can be appropriately set. The second predetermined period may be set according to the valve opening degree.

**[0058]** In Step SA1, in a case where the compressor rotating speed R is equal to or more than the first threshold Rth1 ("NO" in Step SA1), subsequently, it is determined whether the compressor rotating speed R is less than a second threshold Rth2 set to a value larger than the first threshold. (SA6). As a result, in a case where the compressor rotating speed R is less than the second threshold Rth2 (hereinafter, referred to as a "second low speed mode") ("YES" in SA6), the valve 52 is set to the first opening degree, that is, the fully closed state (SA7), and the process is returned to Step SA1.

**[0059]** Meanwhile, in Step SA6, in a case where the compressor rotating speed R is equal to or more than the second threshold Rth2 (hereinafter, referred to as a "high speed mode") ("NO" in SA6), the valve opening degree is set to a second opening degree larger than the first opening degree (SA8), and the process is returned to Step SA1.

**[0060]** Here, the first threshold Rth1 is set to a range which is equal to or more than an orbital speed corresponding to a case where the scroll compressor 1 is operated at 1/2 capacity of a rated operation and is equal to or less than an orbital speed corresponding to a case where the scroll compressor 1 is operated at a capacity of the rated operation. By setting the first threshold to this range, it is possible to expect the suppression of the decrease in efficiency of scroll compressor 1. As an example of the first threshold Rth1, a value of 1/2, 1/3, or 1/4 of a maximum orbital speed of the orbiting scroll 35 can be mentioned. The first threshold Rth1 may be the most frequently used orbital speed of the scroll compressor 1. It is preferable that the first threshold Rth1 is preferably set to a rotating speed range which can allow an oil film formation.

**[0061]** For example, the second threshold Rth2 is set to a value larger than the first threshold value Rth1 in a range which is equal to or more than the orbital speed corresponding to the case where the scroll compressor 1 is operated at 1/2 capacity of a rated operation and is equal to or less than the orbital speed corresponding to the case where the scroll compressor 1 is operated at the capacity of the rated operation.

**[0062]** In the flowchart shown in Fig. 4, the "first predetermined period" is set to a time until an oil temperature in the back pressure chamber 50 reaches an upper limit temperature which is set to be equal to or less than a heat resistance temperature of a peripheral member such as the orbiting scroll 35 and the upper bearing 21. For example, by simulating or testing in real machine the temperature of the oil in the back pressure chamber 50 under various conditions in advance, this first predetermined period can be set from the results. For example, in the state where the valve 52 is fully closed, parameters such as a temperature of a sucked refrigerant, a friction coefficient of the orbiting scroll, an amount of heat given to the back pressure chamber are set to various values, a plurality of simulations are performed, and thus, a temperature increase of the oil in the back pressure chamber 50 is predicted, and an elapsed time until the oil temperature reaches the upper limit temperature is obtained. Accordingly, the first predicted period may be determined from this elapsed time.

**[0063]** For example, the temperature of the back pressure chamber 50 can be estimated using a heat generation amount  $Q_1$  from the upper bearing 21 and an exhaust heat amount  $Q_{oil}$  which is an amount of heat which escapes along the upper bearing 21. For example, the oil temperature  $Toil(n)$  of the back pressure chamber 50 after n seconds from a start of the simulation (in other words, from the state where the valve 52 is closed) can be expressed by the following Expression (1).

[Expression 1]

$$Toil(n) = Toli(n-1) + \frac{Q_1}{Cg \times mg} - \frac{Q_{oil}(n-1)}{Cg \times mg} \quad (1)$$

**[0064]** In addition, the exhaust heat amount  $Q_{oil}$  in Expression (1) can be expanded as in the following equation.

[Expression 2]

$$\begin{aligned}
5 \quad Toil(n) &= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{Qoil(n-1)}{Cg \times mg} \\
&= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{qoli(n-1) \times A}{Cg \times mg} \\
10 \quad &= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{ho(Toil(n-1) - Tw(n-1)) \times A}{Cg \times mg} \\
&= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{hoA}{Cg \times mg} \left\{ Toil(n-1) - \left( Tw(n-2) + \frac{Q'bea}{Cb \times mb} - \frac{Q''bea}{Cb \times mb} \right) \right\} \\
15 \quad &= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{hoA}{Cg \times mg} \left\{ Toil(n-1) - \left( Tw(n-2) + \frac{q'bea(n-1) - q''bea(n-1)}{Cb \times mb} \times A \right) \right\} \\
&= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{hoA}{Cg \times mg} \left\{ Toil(n-1) - \left( Tw(n-2) + \frac{\frac{hb}{L}(Toil(n-1) - Tw(n-1)) - \frac{hb}{L}(Tw(n-1) - Ts)}{Cb \times mb} \times A \right) \right\} \\
20 \quad &= Toil(n-1) + \frac{Q_1}{Cg \times mg} - \frac{hoA}{Cg \times mg} \left\{ Toil(n-1) - \left( Tw(n-2) + \frac{hb(Toil(n-1) + Ts)}{L(Cb \times mb)} \times A \right) \right\}
\end{aligned}$$

25 **[0065]** Various parameters in each of the Expressions are as shown in Table 1 below.

[Table 1]

|    |                                                  |        |                            |
|----|--------------------------------------------------|--------|----------------------------|
| 30 | Drive amount of upper bearing                    | $Q_1$  | [W]                        |
|    | Oil temperature at time of test start            | Toil   | [°C]                       |
|    | Specific heat of oil                             | cq     | [J/ (g·K) ]                |
|    | Mass of oil                                      | mq     | [g]                        |
| 35 | Specific heat of bearing                         | cb     | [J/ (g·K) ]                |
|    | Mass of bearing                                  | mb     | [g]                        |
|    | Heat transfer coefficient of oil                 | ho     | [W/ (mm <sup>2</sup> ·K) ] |
|    | Heat transfer coefficient of bearing             | hb     | [W/ (mm <sup>2</sup> ·K) ] |
| 40 | Compressor suction temperature                   | Ts     | [°C]                       |
|    | Oil-bearing contact length                       | L      | [mm]                       |
|    | Drive bearing area                               | A      | [mm <sup>2</sup> ]         |
| 45 | Bearing wall surface temperature at time of test | Tw     | [°C]                       |
|    |                                                  |        |                            |
|    | Thermal flux of oil                              | qoil   | [W/ (mm <sup>2</sup> ) ]   |
|    | Exhaust heat amount of oil                       | Qoil   | [W]                        |
| 50 | Thermal flux of upper bearing (outside)          | q' bea | [W/ (mm <sup>2</sup> ) ]   |
|    | Exhaust heat amount of upper bearing (outside)   | Q' bea | [W]                        |
|    | Thermal flux of upper bearing (inside)           | q''bea | [W/ (mm <sup>2</sup> ) ]   |
| 55 | Exhaust heat amount of upper bearing (inside)    | Q''bea | [W]                        |

**[0066]** In the simulation, the heat generation amount  $Q_1$  of the upper bearing 21, the oil temperature Toil at a start of test, a temperature Ts of the sucked refrigerant of the scroll compressor 1, and a wall surface temperature Tw of the

upper bearing 21 at the start of test are set to values according to various conditions, and a specific heat  $c_g$  of the oil, a mass  $m_g$  of the oil, a specific heat  $c_b$  of the upper bearing 21, a mass  $m_b$  of the upper bearing 21, a heat transfer coefficient  $h_o$  of the oil, a heat transfer coefficient  $h_b$  of the upper bearing 21, a contact length  $L$  between the oil and the upper bearing 21, and an area  $A$  of the upper bearing 21 are set to values determined from a structure of the scroll compressor 1. In addition, by incorporating the set values into the arithmetic Expressions, a relationship between the elapsed time from the start of the test and the oil temperature in the back pressure chamber 50 can be obtained. From the results, the elapsed time until the oil temperature of the back pressure chamber 50 reaches the upper limit temperature is obtained, and the first predicted period is set from the obtained elapsed times.

**[0067]** The "second predetermined period" is set based on an elapsed time until the temperature of the oil decreases to a preset reference temperature when the valve 52 is changed from the fully closed state to a predetermined opening degree in a case where the temperature of the oil in the back pressure chamber 50 is the upper limit temperature. The second predetermined period can also be simulated in advance and can be derived from the simulation result. The predetermined opening degree can be appropriately adopted. However, the exhaust heat can be promoted as the valve opening degree approaches full opening, and thus, the second predetermined period can be set shorter.

**[0068]** By performing the control as described above, for example, in a case where the compressor rotating speed  $R$  is less than the first threshold  $R_{th1}$ , that is, in a case of the first low speed mode, the valve 52 is set to the fully closed state. Accordingly, it is possible to increase the amount of oil in the back pressure chamber 50, and it is possible to increase the pressure in the back pressure chamber 50. As a result, it is possible to increase the anti-thrust force and it is possible to reduce the thrust loss. Furthermore, after the back pressure chamber 50 is filled with oil, a surplus of the oil flows to a portion between the upper bearing 21 and the orbiting scroll 35. This oil flows into the compression chamber together with the refrigerant, forms an oil film inside the scroll compression mechanism 7, and improves sealing performance. Accordingly, it is possible to suppress the decrease in the efficiency of the scroll compressor 1.

**[0069]** Meanwhile, the valve 52 is fully closed, and thus, a movement of the oil in the back pressure chamber 50 is eliminated, and the oil temperature gradually increases. However, even in this state, in a case where the state where the valve 52 is fully closed is maintained at the first predetermined period, the valve 52 is temporarily opened, and thus, it is possible to discharge the high temperature oil, which stagnates in the back pressure chamber 50, through the oil drain passage 51. Accordingly, it is possible to decrease the temperature of the oil in the back pressure chamber 50, and an influence of the temperature increase of the oil on peripheral parts can be avoided in advance.

**[0070]** In a case where the compressor rotating speed  $R$  is equal to or more than the first threshold  $R_{th1}$  and less than the second threshold  $R_{th2}$ , that is, in a case where the compressor rotating speed is in the second low speed mode, the valve 52 is fully closed. Accordingly, similarly to the above-described first low speed mode, it is possible to suppress the decrease in the efficiency of the scroll compressor 1. In the case of the second low speed mode, unlike the first low speed mode, the control of temporarily opening the valve 52 so as to temporarily increase the flow rate is not performed.

**[0071]** For example, in a region where the compressor rotating speed  $R$  is equal to or less than the first threshold  $R_{th1}$ , an amount of oil pumped from the oil reservoir 3bt to the back pressure chamber 50 is not sufficient, an amount of circulation oil is small, and thus, exhaust heat in a sliding portion such as the upper bearing 21 is not promoted. Accordingly, as described above, it is necessary to temporarily increase the flow rate of the oil flowing through the oil drain passage 51 at a predetermined timing so as to promote the exhaust heat.

**[0072]** Meanwhile, in a region in which the compressor rotating speed  $R$  is equal to or more than the first threshold  $R_{th1}$  and less than the second threshold  $R_{th2}$ , the rotating speed is in a middle speed region, and an amount of oil sufficient for the exhaust heat of the sliding portion is pumped from the oil reservoir 3bt to the back pressure chamber 50. For this reason, unlike when the compressor rotating speed  $R$  is less than or equal to the first threshold  $R_{th1}$ , it is not necessary to temporarily increase the flow rate of the oil flowing through the oil drain passage 51 at a predetermined timing. The oil pumped into the back pressure chamber 50 may flow out from the sliding portion of the orbiting scroll 35 and the fixed scroll 33 and may be returned to the oil reservoir 3bt on the lower portion of the compressor, in addition to the oil drain passage 51.

**[0073]** In a case where the compressor rotating speed  $R$  is equal to or more than the second threshold  $R_{th2}$ , that is, in the case of the high speed mode, the opening degree of the valve 52 is controlled to a second opening degree  $D2$ . As a result, a cold oil flows into the back pressure chamber 50 through the oil supply passage 27, the oil is discharged through the oil drain passage 51, and thus, the temperature increase of the oil in the back pressure chamber 50 can be suppressed. By controlling the valve opening degree of the valve 52 to the second opening degree  $D2$ , the flow rate of the oil increases, and thus, it is possible to suppress an increase in driving power of the oil supply pump 29. As a result, it is possible to suppress the decrease in the efficiency of the scroll compressor 1. Since the amount of the oil flowing from the inside of the back pressure chamber 50 to the portion between the upper bearing 21 and the orbiting scroll 35 is also reduced, the amount of oil included in the refrigerant is also suppressed.

**[0074]** As described above, according to the scroll compressor, the control method therefore, and the air conditioning apparatus according to the present embodiment, in a case where the compressor rotating speed  $R$  is less than the first threshold  $R_{th1}$ , the valve 52 is set to the fully closed state, and the flow rate of the oil flowing through the oil drain

passage 51 is made zero. Therefore, it is possible to effectively increase the pressure in the back pressure chamber 50 and it is possible to increase the anti-thrust force. Accordingly, it is possible to reduce a loss due to friction when the orbiting scroll 35 orbits in the thrust bearing. As a result, it is possible to suppress the decrease in the efficiency of the scroll compressor 1. In addition, the valve 52 is temporarily opened every time the first predetermined period elapses after the valve 52 is fully closed, the flow rate of the oil flowing through the oil drain passage 51 temporarily increases, and thus, it is possible to prevent the oil temperature from increasing too much. Accordingly, it is possible to avoid an influence of heat on a member around the back pressure chamber 50.

**[0075]** In the case where the compressor rotating speed  $R$  is equal to or more than the first threshold  $R_{th1}$  and less than the second threshold  $R_{th2}$ , the state where the valve 52 is fully closed is maintained, as in the first low speed mode, the temporary increase of the flow rate at the predetermined timing is not performed.

**[0076]** In this way, in the case where the compressor rotating speed  $R$  is equal to or more than the first threshold  $R_{th1}$  and less than the second threshold  $R_{th2}$ , the state where the valve 52 is fully closed is maintained. Therefore, it is possible to suppress the decrease in the efficiency of the scroll compressor, it is possible to promote the exhaust heat of the sliding portion such as the bearing, and it is possible to avoid the influence of heat on the member around the back pressure chamber.

**[0077]** In the case where the compressor rotating speed  $R$  is more than the second threshold  $R_{th2}$ , the opening degree of the valve 52 is made larger than the opening degrees of the first and second low speed modes, and the flow rate of the oil flowing through the oil drain passage 51 increases. Accordingly, it is possible to sufficiently perform the exhaust heat while reducing a loss caused by a friction when the orbiting scroll orbits by the anti-thrust force.

**[0078]** Hereinbefore, the present invention is described with reference to the above-described embodiment. However, a technical scope of the present invention is not limited to a range as described in the above-described embodiment. Various changes or improvements can be added to the above-described embodiment within a scope which does not depart from the gist of the invention, and an aspect to which the changes or improvements are added is also included in a technical scope of the present invention.

**[0079]** For example, in the above-described embodiment, in order to ensure that the oil temperature of the back pressure chamber 50 does not exceed the upper limit temperature, the control of temporarily opening the valve 52 is performed in the case where the elapsed time reaches the first predetermined period after the valve 52 is fully closed (refer to SA3 to SA5 of Fig. 4). That is, in the above-described embodiment, the first predetermined period is preset by performing a simulation, a real machine test, or the like in advance, and the valve 52 is temporarily opened and closed using the first predetermined period. Alternatively or additionally, for example, the control device 53 of the scroll compressor 1 further includes a temperature estimation unit which estimates the temperature of the back pressure chamber 50, and when a temperature estimated by the temperature estimation unit reaches the upper limit temperature, the control of temporarily opening the valve 52 may be performed. In this way, by estimating the oil temperature of the back pressure chamber 50 by the temperature estimation unit, for example, it is possible to use an actual measurement value for the temperature of the refrigerant sucked by the above-described scroll compressor 1 and the oil temperature (corresponding to the oil temperature at the start of the test) when the valve 52 is closed. Accordingly, it is possible to reflect an actual ambient environment in the estimation of the oil temperature of the back pressure chamber 50, and to perform temporary opening and closing of the valve 52 at a more appropriate timing.

**[0080]** In the above-described embodiment, the first opening degree is set to zero, that is, the fully closed state. However, the present invention is not limited to this, and the first opening degree may be an opening degree smaller than the second opening degree. In this way, in the case where the compressor rotating speed  $R$  is less than the second threshold, it is possible to discharge a small amount of oil through the oil drain passage 51 by controlling the opening degree of valve 52 to an opening degree that is more open than the fully closed state. Accordingly, it is possible to reliably supply the oil to the sliding portion of the bearing or the like, and thus, the sliding portion can be reliably lubricated.

**[0081]** In the above-described embodiment, by setting the opening degree of the valve 52 to the first opening degree in the case where the compressor rotating speed  $R$  is less than the second opening degree, and setting the opening degree of the valve 52 to the second opening degree in the case where the compressor rotating speed  $R$  is equal to or more than the second opening degree, the valve opening degree is gradually controlled. However, the present invention is not limited to this example. For example, the opening degree of the valve 52 may be set to the first opening degree or more in the case where the compressor rotating speed  $R$  is less than the second opening degree, and the opening degree of the valve 52 may be set to the second opening degree or more in the case where the compressor rotating speed  $R$  is equal to or more than the second opening degree. As an example, the opening degree of the valve 52 may be continuously changed according to the compressor rotating speed  $R$ . By controlling the flow rate of the oil flowing through the oil drain passage 51 in this way, the flow rate of the oil flowing through the oil drain passage 51 can be optimally adjusted over an entire operating range of the scroll compressor 1, and thus, further suppression of the decrease in the efficiency of the scroll compressor 1 can be expected.

**[0082]** Instead of the compressor rotating speed  $R$ , the rotating speed (frequency) of the motor may be used or the speed of the orbiting scroll may be used.

**[0083]** In the above-described embodiment, the valve 52 provided in the oil drain passage 51 is exemplified as an example of the flow rate adjusting mechanism. However, a mechanism for adjusting the flow rate of the oil flowing through the oil drain passage 51 is not limited to the valve 52.

**[0084]** In the above-described embodiment, the valve opening degree of the valve 52 is controlled based on the compressor rotating speed R (the rotating speed of the orbiting scroll 35, the rotating speed of the motor). However, the invention is not limited to this. For example, the valve opening degree of the valve 52 based on the pressure of the refrigerant may be controlled. For example, a pressure difference between the discharge pressure of the refrigerant discharged by the scroll compressor 1 and the suction pressure of the sucked refrigerant can be used as the pressure of the refrigerant. The pressure difference of the refrigerant increases as the rotational speed of the orbiting scroll 35 increases. Accordingly, by performing a control of increasing the opening degree of the valve 52, that is, a control of increasing the flow rate of the oil passing through the oil drain passage 51 according to the increase of the pressure difference of the refrigerant, it is possible to obtain the same effects as those of the above-described control.

#### Reference Signs List

#### **[0085]**

- 1: scroll compressor
- 3: housing
- 3bt: oil reservoir
- 4: outdoor heat exchanger
- 6: electronic expansion valve
- 7: scroll compression mechanism
- 8: indoor heat exchanger
- 10: air conditioning apparatus
- 19: rotary shaft
- 27: oil supply passage
- 33: fixed scroll
- 35: orbiting scroll
- 50: back pressure chamber
- 51: oil drain passage
- 52: valve
- 53: control device

#### **Claims**

##### **1. A scroll compressor comprising:**

a scroll compression mechanism which has a fixed scroll and an orbiting scroll and compresses and discharges a refrigerant between the fixed scroll and the orbiting scroll;  
 a rotary shaft which is a rod-shaped member for orbiting the orbiting scroll;  
 an oil supply passage which is provided inside the rotary shaft along a longitudinal direction and through which oil flowing in from one end of the rotary shaft is discharged from the other end of the rotary shaft;  
 a back pressure chamber which is disposed on the rotary shaft side of the orbiting scroll and into which the oil discharged from the other end of the oil supply passage flows;  
 an oil drain passage through which the oil flowing into the back pressure chamber is discharged;  
 a flow rate adjusting mechanism which changes a flow rate of the oil flowing through the oil drain passage; and  
 a control device which controls the flow rate adjusting mechanism so as to control the flow rate of the oil flowing through the oil drain passage,  
 wherein in a case where an orbital speed of the orbiting scroll is less than a preset first threshold, the control device controls the flow rate of the oil flowing through the oil drain passage to be equal to or less than a preset first flow rate and temporarily increases the flow rate of the oil flowing through the oil drain passage at a predetermined timing determined based on a temperature of the oil in the back pressure chamber, and  
 wherein in a case where the orbital speed of the orbiting scroll is the same as the first threshold or equal to or more than a second threshold set to a value larger than the first threshold, the control device controls the flow rate of the oil flowing through the oil drain passage to be equal to or more than a second flow rate which is a value larger than the first flow rate.

2. The scroll compressor according to claim 1,  
wherein the first threshold is set to be equal to or more than an orbital speed corresponding to a case where the scroll compressor is operated at a capacity of 1/2 of a rated operation and to be equal to or less than an orbital speed corresponding to a case where the scroll compressor is operated at the capacity of the rated operation.
3. The scroll compressor according to claim 1 or 2,  
wherein in a case where the orbital speed of the orbiting scroll is equal to or more than the first threshold and is less than the second threshold set to the value larger than the first threshold, the control device controls the flow rate of the oil flowing through the oil drain passage to be in a range of the first flow rate to the second flow rate.
4. The scroll compressor according to any one of claims 1 to 3,  
wherein a timing at which a temperature of the oil in the back pressure chamber reaches a preset upper limit temperature is estimated or tested in advance, and the predetermined timing is determined in advance based on a result of the estimation or test.
5. The scroll compressor according to any one of claims 1 to 4, further comprising:  
  
a temperature estimation unit which estimates the temperature of the oil in the back pressure chamber,  
wherein in a case where the temperature of the oil estimated by the temperature estimation unit is equal to or more than a preset upper limit temperature, the control device determines that the predetermined timing reaches and temporarily increases the flow rate of the oil flowing through the oil drain passage.
6. An air conditioning apparatus comprising:  
  
a condenser which condenses a refrigerant;  
an evaporator which evaporates the refrigerant condensed by the condenser; and  
the scroll compressor according to any one of claims 1 to 5 which compresses the refrigerant evaporated by the evaporator.
7. A control method of a scroll compressor including a scroll compression mechanism which has a fixed scroll and an orbiting scroll and compresses and discharges a refrigerant between the fixed scroll and the orbiting scroll, a rotary shaft which is a rod-shaped member for orbiting the orbiting scroll, an oil supply passage which is provided inside the rotary shaft along a longitudinal direction and through which oil flowing in from one end of the rotary shaft is discharged from the other end of the rotary shaft, a back pressure chamber which is disposed on the rotary shaft side of the orbiting scroll and into which the oil discharged from the other end of the oil supply passage flows, and an oil drain passage through which the oil flowing into the back pressure chamber is discharged, the method comprising:  
  
in a case where an orbital speed of the orbiting scroll is less than a preset first threshold, controlling the flow rate of the oil flowing through the oil drain passage to be equal to or less than a preset first flow rate and temporarily increasing the flow rate of the oil flowing through the oil drain passage at a predetermined timing determined based on a temperature of the oil in the back pressure chamber; and  
in a case where the orbital speed of the orbiting scroll is the same as the first threshold or equal to or more than a second threshold set to a value larger than the first threshold, controlling the flow rate of the oil flowing through the oil drain passage to be equal to or more than a second flow rate which is a value larger than the first flow rate.

FIG. 1

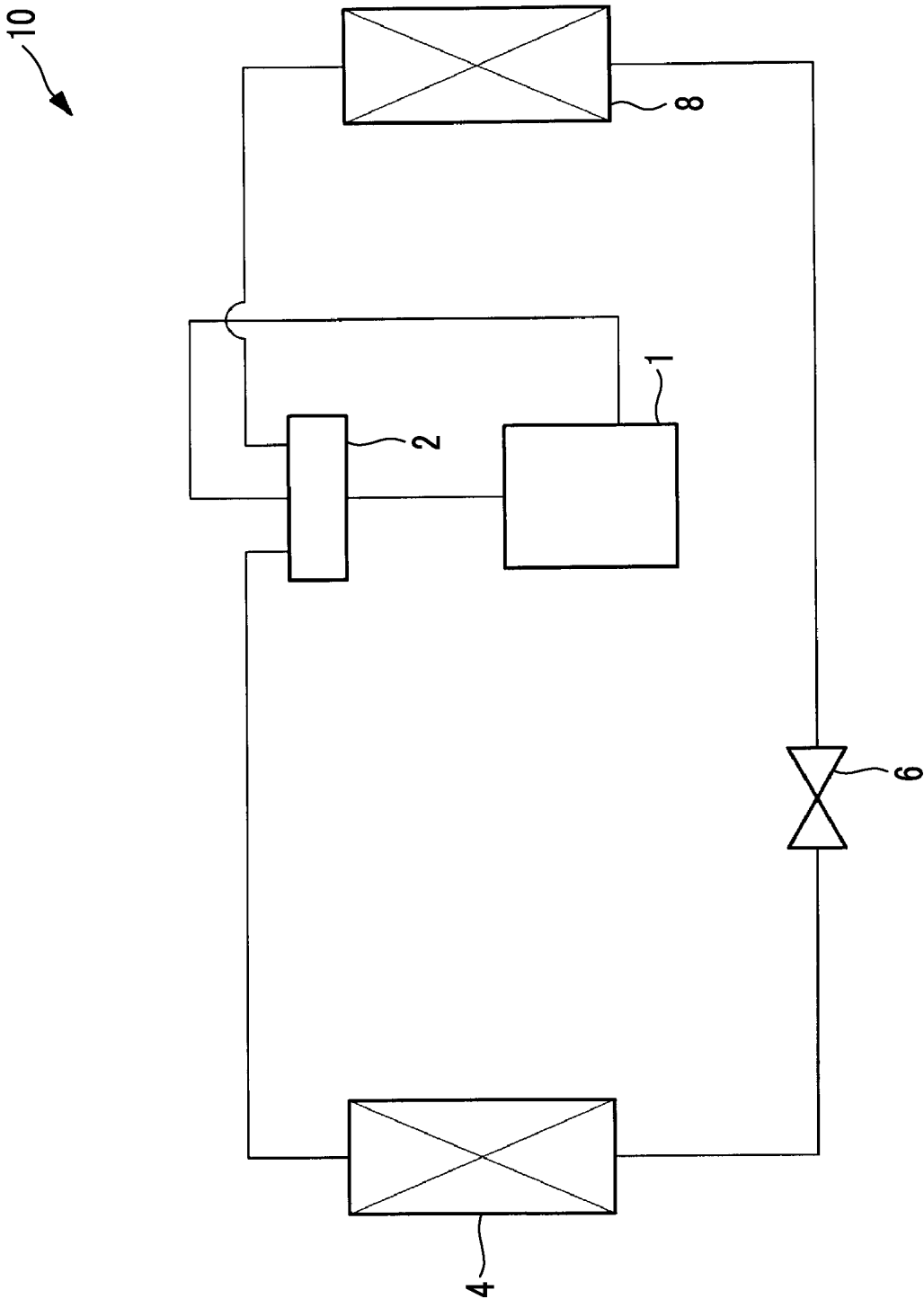


FIG. 2

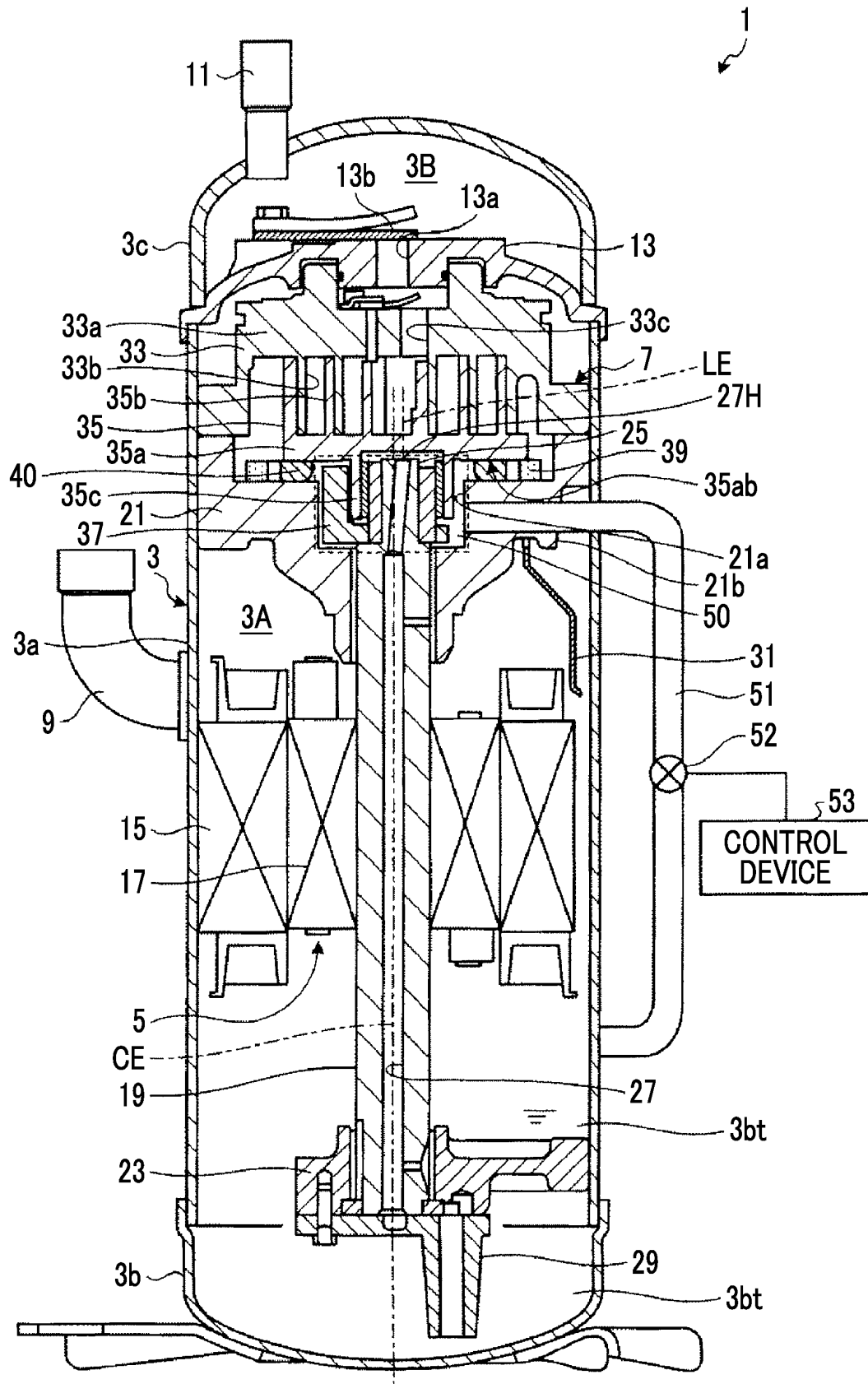


FIG. 3

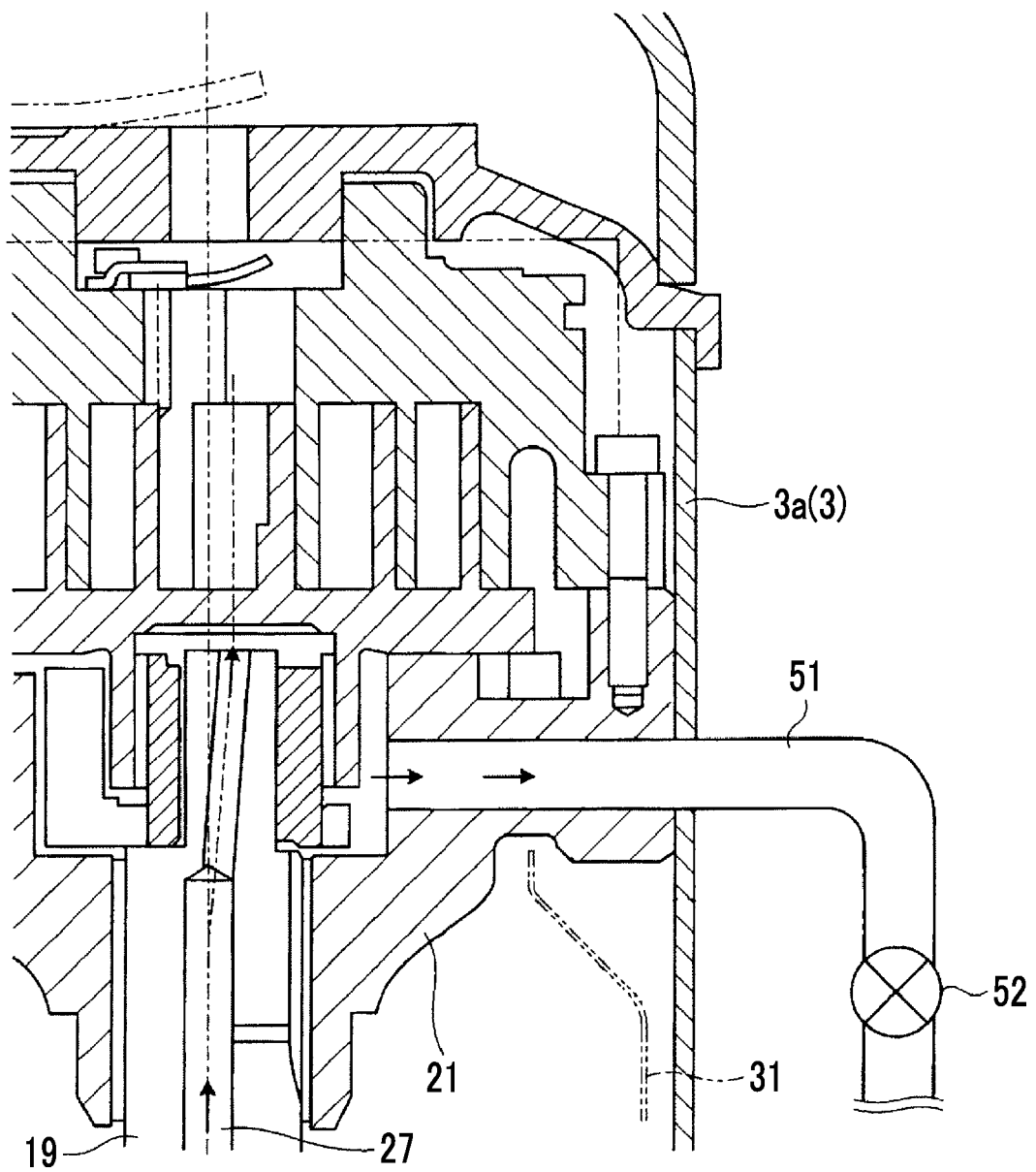
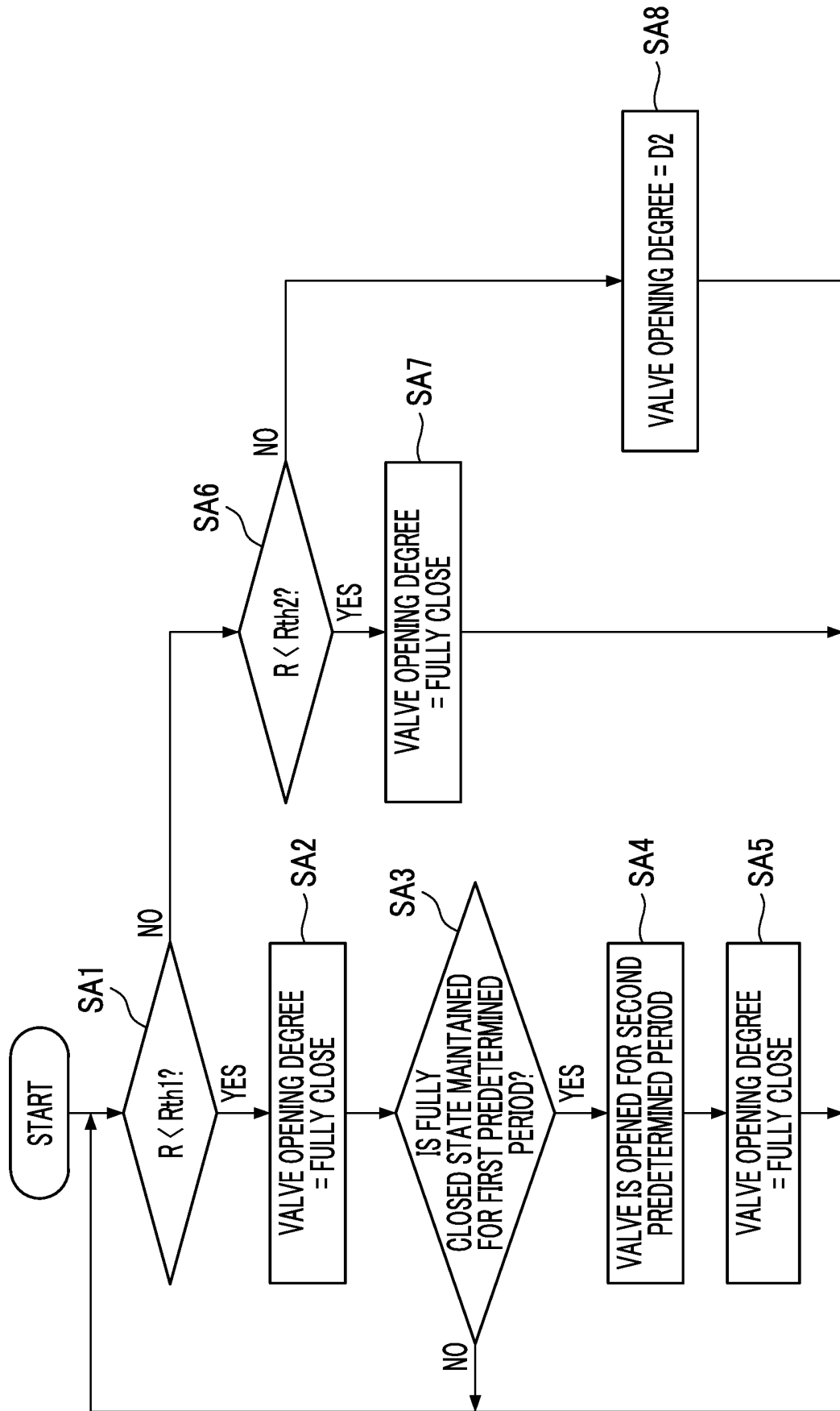


FIG. 4



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/029516

## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. 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)

Int.Cl. F04C18/02

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                 | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | WO 2017/073213 A1 (MITSUBISHI HEAVY INDUSTRIES, LTD.) 04 May 2017, paragraphs [0021]-[0059], [0080]-[0082], fig. 1, 2, 9 & EP 3301302 A1, paragraphs [0021]-[0059], [0080]-[0082], fig. 1, 2, 9 & JP 2017-82718 A & CN 107709784 A | 1-7                   |

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

\* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

04.10.2018

Date of mailing of the international search report

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Telephone No.

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- WO 2017073213 A [0004]