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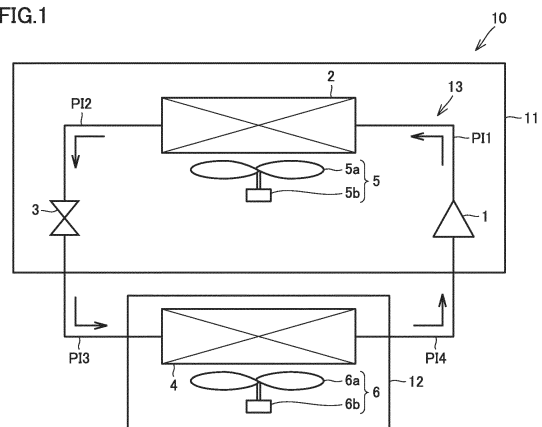
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(54) **AIR CONDITIONER**

(57) An air conditioner (10) includes a refrigerant circuit (13) and refrigerant. The refrigerant circuit (13) has a compressor (1), a condenser (2), a pressure-regulating valve (3), and an evaporator (4). The refrigerant is R32. The pressure-regulating valve (3) includes a flow path (33) causing the refrigerant flowing from the condenser (2) to flow to the evaporator (4), a pressure reference chamber (S2) partitioned from the flow path (33) and filled with inert gas, and a valve portion (34) disposed in the flow path (33). The pressure-regulating valve (3) is configured to adjust a degree of opening of the valve portion (34) to adjust a flow rate of the refrigerant flowing through the flow path (33). The valve portion (34) is configured to increase the degree of opening when a pressure in the flow path (33) is higher than a pressure in the pressure reference chamber (S2), and reduce the degree of opening when the pressure in the flow path (33) is lower than the pressure in the pressure reference chamber (S2).

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to air conditioners.

BACKGROUND ART

[0002] Air conditioners that reduce refrigerant consumption with the use of low global warming potential (GWP) refrigerant are desired in consideration of global environment. Used as the refrigerant enabling such air conditioners that reduce refrigerant consumption with the use of low GWP refrigerant is R32. R32 is refrigerant which has a small polytropic exponent and whose temperature easily increases when discharged from a compressor. The use of R32 as refrigerant thus easily increases the temperature of the refrigerant discharged from the compressor at high outside temperature and at high condensation temperature. Since an increase in the temperature of the refrigerant discharged from the compressor may lead to a failure of the compressor, the temperature of the refrigerant discharged from the compressor is desired not to exceed a set temperature in order to prevent a failure of the compressor.

[0003] In a conventional air conditioner using R32 as refrigerant, thus, a linear expansion valve (LEV) is used to adjust the temperature of the refrigerant discharged from a compressor. Specifically, a microcomputer controls the degree of opening of the LEV based on a signal from a thermistor that has detected the temperature of the refrigerant discharged from the compressor to adjust the temperature of the refrigerant discharged from the compressor not to exceed the set temperature.

[0004] For example, Japanese Patent Laying-Open No. 2016-109356 (PTL 1) discloses an air conditioner that uses R32 as refrigerant and includes an LEV.

CITATION LIST

PATENT LITERATURE

[0005] PTL 1: Japanese Patent Laying-Open No. 2016-109356

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] The air conditioner disclosed in the above literature has a long response time of the temperature of the refrigerant discharged from the compressor with respect to the adjustment of the degree of opening of the LEV. Consequently, the adjustment of the degree of opening of the LEV may not keep up with an increase in the temperature of the refrigerant discharged from the compressor, allowing the temperature of the refrigerant dis-

charged from the compressor to exceed the set temperature. A reduced amount of refrigerant may lead to a shorter response time of the temperature of the refrigerant discharged from the compressor with respect to the adjustment of the degree of opening of the LEV. As a result, even when the degree of opening of the LEV is adjusted to allow the temperature of the refrigerant discharged from the compressor to be equal to the set temperature, a phenomenon (hunting) occurs in which the temperature of the refrigerant discharged from the compressor exceeds or falls below the set temperature.

[0007] The present invention has been made in view of the above problem and has an object to provide an air conditioner that can suppress an increase in the temperature of refrigerant discharged from a compressor and reduce refrigerant consumption with the use of low GWP refrigerant.

SOLUTION TO PROBLEM

[0008] An air conditioner of the present invention includes a refrigerant circuit and refrigerant. The refrigerant circuit has a compressor, a condenser, a pressure-regulating valve, and an evaporator. The refrigerant flows through the refrigerant circuit in the order of the compressor, the condenser, the pressure-regulating valve, and the evaporator. The refrigerant is R32. The pressure-regulating valve includes a flow path causing the refrigerant flowing from the condenser to flow to the evaporator, a pressure reference chamber partitioned from the flow path and filled with inert gas, and a valve portion disposed in the flow path. The pressure-regulating valve is configured to adjust a degree of opening of the valve portion to adjust a flow rate of the refrigerant flowing through the flow path. The valve portion is configured to increase the degree of opening when a pressure in the flow path is higher than a pressure in the pressure reference chamber and reduce the degree of opening when the pressure in the flow path is lower than the pressure in the pressure reference chamber.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] The air conditioner of the present invention sets the pressure in the pressure reference chamber to the pressure in the flow path where the temperature of the refrigerant discharged from the compressor is a set temperature, and accordingly can increase the degree of opening of the valve portion when the pressure in the flow path is higher than the pressure in the pressure reference chamber, thus suppressing the temperature of the refrigerant discharged from the compressor exceeding the set temperature. Also, the degree of opening of the valve portion is adjusted before the temperature of the refrigerant discharged from the compressor exceeds the set temperature, thus suppressing the generation of hunting. R32 is low GWP refrigerant. Therefore, an air conditioner that reduces refrigerant consumption with the

use of low GWP refrigerant can be achieved.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 schematically shows the structure of a refrigerant circuit of an air conditioner in Embodiment 1 of the present invention.

Fig. 2 is a sectional view schematically showing the structure of a pressure-regulating valve of the air conditioner in Embodiment 1 of the present invention.

Fig. 3 is a sectional view for illustrating an operation of a valve portion of the air conditioner in Embodiment 1 of the present invention.

Fig. 4 schematically shows the structure of a refrigerant circuit of an air conditioner in a comparative example.

Fig. 5 schematically shows the structure of a refrigerant circuit of an air conditioner in Embodiment 2 of the present invention.

Fig. 6 schematically shows the structure of a refrigerant circuit of an air conditioner in Embodiment 3 of the present invention.

Fig. 7 is a sectional view schematically showing the structure of a pressure-regulating valve of a modification of the air conditioner in Embodiment 3 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0011] Embodiments of the present invention will be described below with reference to the drawings.

Embodiment 1

[0012] A configuration of an air conditioner 10 in Embodiment 1 of the present invention will be described with reference to Fig. 1. Air conditioner 10 of the present embodiment is a device dedicated to cooling. That is to say, air conditioner 10 of the present embodiment has a cooling function and does not have a heating function.

[0013] Air conditioner 10 of the present embodiment mainly includes a compressor 1, a condenser 2, a pressure-regulating valve 3, an evaporator 4, a blower for condenser 5, a blower for evaporator 6, pipes PI1 to PI4, and refrigerant. Compressor 1, condenser 2, pressure-regulating valve 3, and blower for condenser 5 are accommodated in an outdoor unit 11. Evaporator 4 and blower for evaporator 6 are accommodated in an indoor unit 12.

[0014] Refrigerant circuit 13 has compressor 1, condenser 2, pressure-regulating valve 3, and evaporator 4. Compressor 1, condenser 2, pressure-regulating valve 3, and evaporator 4 communicated with each other through pipes PI1 to PI4 constitute refrigerant circuit 13. Specifically, compressor 1 and condenser 2 are connect-

ed to each other by pipe PI1. Condenser 2 and pressure-regulating valve 3 are connected to each other by pipe PI2. Pressure-regulating valve 3 and evaporator 4 are connected to each other by pipe PI3. Evaporator 4 and compressor 1 are connected to each other by pipe PI4.

[0015] Refrigerant circuit 13 is configured to allow refrigerant to circulate therethrough in the order of compressor 1, pipe PI1, condenser 2, pipe PI2, pressure-regulating valve 3, pipe PI3, evaporator 4, and pipe PI4. That is to say, refrigerant flows through refrigerant circuit 13 in the order of compressor 1, condenser 2, pressure-regulating valve 3, and evaporator 4. Refrigerant is R32. The amount of the refrigerant flowing through refrigerant circuit 13 is preferably 300 g or more and 500 g or less.

[0016] Compressor 1 is configured to compress refrigerant. Compressor 1 is also configured to compress the sucked refrigerant and discharge the compressed refrigerant. Compressor 1 is configured to have a variable capacity. Compressor 1 of the present embodiment is configured to variably control the number of rotations. Specifically, the drive frequency of compressor 1 is changed based on an instruction from a controller (not shown), so that the number of rotations of compressor 1 is adjusted. This changes the capacity of compressor 1. The capacity of compressor 1 is an amount by which refrigerant is fed per unit time. That is to say, compressor 1 can perform a high-capacity operation and a low-capacity operation. In the high-capacity operation, an operation is performed by setting the drive frequency of compressor 1 high to increase the flow rate of refrigerant circulating through refrigerant circuit 13. In the low-capacity operation, an operation is performed by setting the drive frequency of compressor 1 low to reduce the flow rate of refrigerant circulating through refrigerant circuit 13.

[0017] Condenser 2 is configured to condense the refrigerant compressed by compressor 1. Condenser 2 is an air-heat exchanger formed of a pipe and a fin. Pressure-regulating valve 3 is configured to decompress the refrigerant condensed by condenser 2. Pressure-regulating valve 3 has the function as an expansion valve. Pressure-regulating valve 3 is also a mechanical pressure control valve. Pressure-regulating valve 3 is also configured to adjust the flow rate of the refrigerant flowing through pressure-regulating valve 3. The flow rate of the refrigerant flowing through pressure-regulating valve 3 is a flow rate per unit time. Evaporator 4 is configured to evaporate the refrigerant decompressed by pressure-regulating valve 3. Evaporator 4 is an air-heat exchanger formed of a pipe and a fin.

[0018] Blower for condenser 5 is configured to adjust a heat exchange amount between the outdoor air and refrigerant in condenser 2. Blower for condenser 5 is formed of a fan 5a and a motor 5b. Motor 5b may be configured to rotate fan 5a such that the number of rotations of fan 5a is variable. Motor 5b may also be configured to rotate fan 5a such that the number of rotations of fan 5a is constant. Blower for evaporator 6 is configured to adjust a heat exchange amount between the in-

door air and refrigerant in evaporator 4. Blower for evaporator 6 is formed of a fan 6a and a motor 6b. Motor 6b may be configured to rotate fan 6a such that the number of rotations of fan 6a is variable. Motor 6b may be configured to rotate fan 6a such that the number of rotations of fan 6a is constant.

[0019] With reference to Figs. 1 and 2, the configuration of pressure-regulating valve 3 in the present embodiment will be described in detail.

[0020] Pressure-regulating valve 3 includes a case 31, a diaphragm 32, a flow path 33, a valve portion 34, a spring 35, and a partition member 36. Pressure-regulating valve 3 is configured to adjust the degree of opening of valve portion 34 to adjust the flow rate of the refrigerant flowing through flow path 33.

[0021] Diaphragm 32 is attached to the inner side of case 31 to partition the interior of case 31. Case 31 has a first chamber S1 and a second chamber S2 partitioned by diaphragm 32.

[0022] First chamber S1 has flow path 33 which causes the refrigerant flowing from condenser 2 to flow to evaporator 4. Specifically, first chamber S1 has a flow inlet portion 31a and a flow outlet portion 31b. Flow inlet portion 31a is connected to pipe PI2. Flow outlet portion 31b is connected to pipe PI3. First chamber S1 is configured to allow the refrigerant flowing through the refrigerant circuit to flow from pipe PI2 through flow inlet portion 31a into first chamber S1 and then flow through outlet portion 31b to pipe PI3. That is to say, the refrigerant flowing through the refrigerant circuit flows into first chamber S1 from flow inlet portion 31a and flows out of flow outlet portion 31b, as indicated by arrows A1 in Fig. 2. In the present embodiment, the path from flow inlet portion 31a to flow outlet portion 31b forms flow path 33 for refrigerant.

[0023] The pressure of first chamber S1 is a pressure of the refrigerant in flow path 33. Since the pressure of first chamber S1 is a pressure of the refrigerant flowing thereinto from condenser 2, it is a pressure of high-pressure-side refrigerant flowing through refrigerant circuit 13. Pressure-regulating valve 3 is accordingly a high-pressure pressure-regulating valve.

[0024] Second chamber S2 forms a pressure reference chamber S2. Pressure reference chamber S2 is partitioned from flow path 33. Pressure reference chamber S2 is filled with inert gas. Pressure reference chamber S2 is hermetically sealed while being filled with inert gas. The pressure in pressure reference chamber S2 is a pressure of the inert gas. The inert gas is, for example, nitrogen or helium. Nitrogen is advantageous in low cost. Helium is advantageous in high level of safety. The pressure in pressure reference chamber S2 is, for example, 3 MPa or more and 4 MPa or less.

[0025] Diaphragm 32 is configured to deform in the direction indicated by a double-pointed arrow A2 in Fig. 2 due to a pressure difference between the pressure of first chamber S1 and the pressure of second chamber S2, that is, a pressure difference between the pressure of

the refrigerant in flow path 33 and the pressure of the inert gas in pressure reference chamber S2. Specifically, diaphragm 32 is configured to curve in a projecting manner toward pressure reference chamber S2 when the pressure of the refrigerant in flow path 33 is higher than the pressure of the inert gas in pressure reference chamber S2. In contrast, diaphragm 32 is configured to be planar when the pressure of the refrigerant in flow path 33 is equal to or lower than the pressure of the inert gas in pressure reference chamber S2. That is to say, in this case, diaphragm 32 does not curve in a projecting manner toward pressure reference chamber S2.

[0026] Valve portion 34, spring 35, and partition member 36 are disposed in first chamber S1. Partition member 36 is configured to partition first chamber S1 into a first region on the flow inlet portion 31a side and a second region on the flow outlet portion 31b side. That is to say, partition member 36 is disposed between flow inlet portion 31a and flow outlet portion 31b in flow path 33 extending from flow inlet portion 31a to flow outlet portion 31b.

[0027] Valve portion 34 has a valve body 34a and a valve seat 34b. Valve portion 34 is configured to adjust the degree of opening by the gap between valve body 34a and valve seat 34b. Valve body 34a is formed in a shaft shape. One end (first end) of valve body 34a is connected to diaphragm 32. The other end (second end) of valve body 34a is connected to spring 35. Valve body 34a is configured to move in the direction indicated by a double-pointed arrow A3 in Fig. 2 due to the deformation of diaphragm 32. That is to say, valve body 34a is configured to move in the axial direction of valve body 34a due to the deformation of diaphragm 32. Valve body 34a has a tapered shape with a cross-section continuously decreasing from the one end to the other end. Valve body 34a is formed in a truncated cone shape and is formed with a diameter continuously decreasing in the axial direction toward valve seat 34b.

[0028] Valve seat 34b is provided in partition member 36. Valve seat 34b is disposed between flow inlet portion 31a and flow outlet portion 31b in flow path 33 extending from flow inlet portion 31a to flow outlet portion 31b. Valve seat 34b is provided around a valve hole 37 passing through valve seat 34b. Valve body 34a moves in the axial direction of valve body 34a due to the deformation of diaphragm 32 and accordingly leaves valve seat 34b, thereby opening valve hole 37. Specifically, when the pressure of the refrigerant in flow path 33 exceeds the pressure of the inert gas in pressure reference chamber S2, diaphragm 32 curves in a projecting manner toward pressure reference chamber S2. This causes valve body 34a connected to diaphragm 32 to move toward pressure reference chamber S2 in the axial direction of valve body 34a. The other end of valve body 34a accordingly leaves valve seat 34b to expose valve hole 37 from valve body 34a, thereby opening valve hole 37.

[0029] Valve seat 34b is configured such that each of the surface (upper surface) on the first region side of first

chamber S1 and the surface (lower surface) on the second region side of first chamber S1 becomes dented. That is to say, valve seat 34b has a dent on each of the first region side and the second region side of first chamber S1. In valve seat 34b, the bottom of the dent on the first region side of first chamber S1 and the bottom of the dent on the second region side of first chamber S1 are communicated with each other. The bottom of the dent on the first region side of first chamber S1 and the bottom of the dent on the second region side of first chamber S1 which are communicated with each other define valve hole 37.

[0030] Specifically, valve seat 34b is formed such that each of the surface on the first region side of first chamber S1 and the surface on the second region side of first chamber S1 is formed in a cone shape. Valve seat 34b is formed in a cone shape such that the surface on the first region side of first chamber S1 has a diameter continuously decreasing toward the second region of first chamber S1. The surface of valve seat 34b on the first region side of first chamber S1 is formed in a cone shape to have a diameter continuously decreasing toward second region of first chamber S1.

[0031] Valve portion 34 is configured to increase the degree of opening when the pressure in flow path 33 is higher than the pressure in pressure reference chamber S1. That is to say, valve portion 34 is configured as follows. When the pressure in flow path 33 is higher than the pressure in pressure reference chamber S2, valve body 34a moves toward diaphragm 32 in the axial direction of valve body 34a to increase the gap between valve body 34a and valve seat 34b, thereby increasing the degree of opening. Valve portion 34 is also configured to reduce the degree of opening when the pressure in flow path 35 is lower than the pressure in pressure reference chamber S2. That is to say, valve portion 34 is configured as follows. When the pressure in flow path 35 is lower than the pressure in pressure reference chamber S2, valve body 34a moves toward spring 35 in the axial direction of valve body 34a to reduce the gap between valve body 34a and valve seat 34b, thereby reducing the degree of opening.

[0032] Valve portion 34 is configured to continuously change the size of the gap between valve body 34a and valve seat 34b by valve body 34a moving in the axial direction of valve body 34a due to the deformation of diaphragm 32. That is to say, valve portion 34 is configured to increase or reduce the degree of opening of valve portion 34 in proportional to the amount of movement in the axial direction of valve body 34a.

[0033] Spring 35 is connected to the other end of valve body 34a and the bottom of case 31. Spring 35 is configured to bias valve body 34a toward the bottom of case 31 by elastic force.

[0034] A small hole 38 is provided in partition member 36. Small hole 38 is provided to pass through partition member 36. Small hole 38 defines a part of flow path 33. Since small hole 38 is not closed by valve body 34a and

is open constantly, refrigerant can constantly flow through small hole 38 from the first region to the second region in first chamber S1. In the present embodiment, small hole 38 has the function as a capillary. That is to say, the refrigerant is decompressed by flowing through small hole 38.

[0035] A flow of refrigerant in the refrigerant circuit of air conditioner 10 of the present embodiment will now be described.

[0036] With reference to Fig. 1, the refrigerant that has flowed into compressor 1 is compressed by compressor 1 to turn into high-temperature, high-pressure gas refrigerant. The high-temperature, high-pressure gas refrigerant discharged from compressor 1 flows through pipe P11 into condenser 2. The refrigerant that has flowed into condenser 2 is subjected to heat exchange with the air in condenser 2. Specifically, in condenser 2, the refrigerant is condensed by heat dissipation to the air, and the air is heated by the refrigerant. High-pressure liquid refrigerant condensed by condenser 2 flows through pipe P12 into pressure-regulating valve 3.

[0037] The refrigerant that has flowed into pressure-regulating valve 3 is decompressed by pressure-regulating valve 3 to turn into low-pressure gas-liquid two-phase refrigerant. The refrigerant decompressed by pressure-regulating valve 3 flows through pipe P13 into evaporator 4. The refrigerant that has flowed into evaporator 4 is subjected to heat exchange with the air in evaporator 4. Specifically, in evaporator 4, the air is cooled by the refrigerant, and the refrigerant turns into low-pressure gas refrigerant. The refrigerant decompressed by evaporator 4 to turn into low-pressure gas flows through pipe P14 into compressor 1. The refrigerant flowing into compressor 1 is compressed and pressurized again and subsequently discharged from compressor 1.

[0038] With reference to Figs. 2 and 3, the operation of pressure-regulating valve 3 in the present embodiment will now be described in detail.

[0039] When the pressure of the refrigerant in flow path 33 is equal to or lower than the pressure of the inert gas in pressure reference chamber S2, diaphragm 32 is maintained in a planar manner, so that valve body 34a is in contact with valve seat 34b. This maintains the state in which valve hole 37 is closed by valve body 34a. Valve portion 34 is closed in this state.

[0040] When the pressure of the refrigerant in flow path 33 is higher than the pressure of the inert gas in pressure reference chamber S2, diaphragm 32 deforms in a projecting manner toward pressure reference chamber S2. The deformation of diaphragm 32 causes valve body 34a to move toward pressure reference chamber S2 in the axial direction of valve body 34a. Consequently, valve body 34a leaves valve seat 34b. In this state, valve portion 34 is opened. Further, when valve body 34a moves toward pressure reference chamber S2 in the axial direction of valve body 34a due to the deformation of diaphragm 32, the gap between valve body 34a and valve seat 34b increases. That is to say, the degree of opening

of valve portion 34 increases. This increases the amount of refrigerant flowing through pressure-regulating valve 3, thus increasing the amount of refrigerant flowing into evaporator 4. The degree of superheat (SH) accordingly decreases. As a result, an increase in the temperature of the refrigerant discharged from compressor 1 can be suppressed.

[0041] The amount of movement in the axial direction of valve body 34a can be adjusted by the pressure of the refrigerant in flow path 33, the pressure of the inert gas in pressure reference chamber S2, and the biasing force of spring 35 connected to valve body 34a. The degree of opening of valve portion 34 can be adjusted by the gap between valve body 34a and valve seat 34b. The amount of the refrigerant flowing through pressure-regulating valve 3 can thus be adjusted by adjusting the amount of movement in the axial direction of valve body 34a and the degree of opening of valve portion 34.

[0042] The function and effect of the present embodiment will now be described in comparison with those of a comparative example. The same components as those of Embodiment 1 will be denoted by the same reference signs, and description thereof will not be repeated, unless otherwise noted.

[0043] With reference to Fig. 4, air conditioner 10 of the comparative example differs from air conditioner 10 of the present embodiment in that it includes a linear expansion valve (LEV) 30, a thermistor 7, and a microcomputer 8. In air conditioner 10 of the comparative example, microcomputer 8 controls the degree of opening of LEV 30 based on a signal from thermistor 7 that has detected the temperature of the refrigerant discharged from compressor 1, so that the temperature of the refrigerant discharged from compressor 1 is adjusted not to exceed a set temperature (a temperature set to prevent a failure of compressor 1).

[0044] In air conditioner 10 of the present embodiment, refrigerant is R32. R32 is refrigerant which has a small polytropic exponent and whose temperature easily increases when discharged from compressor 1. Thus, when R32 is used as refrigerant, the temperature of the refrigerant discharged from compressor 1 increases easily at high outside air (high outside air temperature) and at high condensation temperature.

[0045] Air conditioner 10 of the present embodiment sets the pressure in pressure reference chamber S2 to the pressure in flow path 33 where the temperature of the refrigerant discharged from compressor 1 is the set temperature (the temperature set to prevent a failure of compressor 1), thereby increasing the degree of opening of valve portion 34 when the pressure in flow path 33 is higher than the pressure in pressure reference chamber S2. This can suppress the temperature of the refrigerant discharged from compressor 1 exceeding the set temperature. The amount of the refrigerant flowing into evaporator 4 can also be increased by increasing the amount of the refrigerant flowing through pressure-regulating valve 3, thus reducing the degree of superheat. An in-

crease in the temperature of the refrigerant discharged from compressor 1 can thus be suppressed. Also, the generation of hunting can be suppressed by adjusting the degree of opening of valve portion 34 before the temperature of the refrigerant discharged from compressor 1 exceeds the set temperature. R32 is low GWP refrigerant. Consequently, air conditioner 10 that reduces refrigerant consumption with the use of low GWP refrigerant can be achieved.

[0046] Air conditioner 10 of the comparative example needs LEV 30, thermistor 7, and microcomputer 8 to adjust the temperature of the refrigerant discharged from compressor 1, leading to a complex configuration of air conditioner 10. Also, the cost of manufacturing air conditioner 10 is increased. Contrastingly, in air conditioner 10 of the present embodiment, pressure-regulating valve 3 can adjust the temperature of the refrigerant discharged from compressor 1, leading to a simple configuration of air conditioner 10. Also, the cost of manufacturing air conditioner 10 is reduced.

[0047] In air conditioner 10 of the present embodiment, pressure-regulating valve 3 can adjust the flow rate of the refrigerant flowing through flow path 33 by adjusting the degree of opening of valve portion 34. Thus, the generation of hunting can be suppressed more than in the case where valve portion 34 is merely opened/closed (ON/OFF). Also, the controllability of the flow rate of refrigerant can be improved.

[0048] In air conditioner 10 of the present embodiment, the amount of refrigerant flowing through refrigerant circuit 13 is 300 g or more and 500 g or less. According to the documents provided by the Ministry of Economy, Trade and Industry (documents related to a method of estimating emissions outside notification, 2003), the average refrigerant chlorofluorocarbon (CFC) charge amount of a room air conditioner is 800 g. Air conditioner 10 of the present embodiment can thus reduce the amount of refrigerant to about a half of 800 g that is the average refrigerant CFC charge amount of a room air conditioner. If the amount of refrigerant is 400 g $\pm$ 100 g, where 400 g is a half of the average refrigerant CFC charge amount of a room air conditioner, the refrigerant consumption can be reduced while maintaining the cooling capacity.

[0049] In air conditioner 10 of the comparative example, a reduced amount of refrigerant results in a shorter response time of the temperature of the refrigerant discharged from compressor 1 with respect to the adjustment of the degree of opening of LEV 30, so hunting may occur at the set temperature. Contrastingly, air conditioner 10 of the present embodiment increases the degree of opening of valve portion 34 with reference to the pressure in pressure reference chamber S2, thereby suppressing the generation of hunting with respect to the set temperature even when the amount of refrigerant decreases. Controllability can thus be improved.

[0050] In air conditioner 10 of the present embodiment, compressor 1 can variably control the number of rota-

tions. Power consumption can thus be reduced by variably controlling the number of rotations of compressor 1. Also, even when the temperature of the refrigerant discharged from compressor 1 increases due to an increase in the number of rotations of compressor 1, an increase in the temperature of the refrigerant discharged from compressor 1 can be suppressed by increasing the degree of opening of valve portion 34 with reference to the pressure in pressure reference chamber S2.

Embodiment 2

[0051] The same components as those of Embodiment 1 will be denoted by the same reference signs in Embodiment 2, and description thereof will not be repeated, unless otherwise noted.

[0052] With reference to Fig. 5, air conditioner 10 of Embodiment 2 of the present invention differs from air conditioner 10 of Embodiment 1 in the configuration of pressure-regulating valve 3.

[0053] In air conditioner 10 of the present embodiment, pressure-regulating valve 3 includes a capillary 39. Capillary 39 is connected to case 31 of pressure-regulating valve 3 and evaporator 4. The configuration in case 31 of pressure-regulating valve 3 is identical to the configuration of Embodiment 1. Capillary 39 is disposed between valve portion 34 and evaporator 4 in refrigerant circuit 13. Capillary 39 can thus decompress the refrigerant.

[0054] The present embodiment can adjust the decompression of refrigerant by capillary 39. This leads to easier adjustment of the decompression of the refrigerant.

Embodiment 3

[0055] The same components as those of Embodiment 1 will be denoted by the same reference signs in Embodiment 3, and description thereof will not be repeated, unless otherwise noted.

[0056] With reference to Fig. 6, air conditioner 10 of Embodiment 3 of the present invention differs from air conditioner 10 of Embodiment 1 in the configuration of pressure-regulating valve 3.

[0057] In air conditioner 10 of the present embodiment, pressure-regulating valve 3 includes capillary 39. Capillary 39 is connected in parallel with case 31 of pressure-regulating valve 3 in refrigerant circuit 13. The configuration in case 31 of pressure-regulating valve 3 is identical to the configuration of Embodiment 1. Capillary 39 is disposed in parallel with valve portion 34 in refrigerant circuit 13. Capillary 39 can thus decompress the refrigerant.

[0058] The present embodiment can accordingly adjust the decompression of refrigerant by capillary 39. The adjustment of the decompression of refrigerant can thus be simplified.

[0059] With reference to Fig. 7, a modification of air conditioner 10 of Embodiment 3 will now be described.

This modification differs from Embodiment 1 in that small hole 38 is not provided. In this modification, capillary 39 is disposed in parallel with valve portion 34 in refrigerant circuit 13, and accordingly, capillary 39 can cause refrigerant to constantly flow through refrigerant circuit 13 even when small hole 38 of Embodiment 1 is not provided.

[0060] Capillary 39 can adjust the decompression of refrigerant more easily than small hole 38 of Embodiment 1. In the modification of air conditioner 10 of the present embodiment, thus, capillary 39 can adjust the decompression of refrigerant easily.

[0061] It is to be understood that the embodiments disclosed herein have been presented for the purpose of illustration and non-restrictive in every respect. It is therefore intended that the scope of the present invention is defined by claims, not only by the embodiments described above, and encompasses all modifications and variations equivalent in meaning and scope to the claims.

REFERENCE SIGNS LIST

[0062] 1 compressor, 2 condenser, 3 pressure-regulating valve, 4 evaporator, 5 blower for condenser, 6 blower for evaporator, 7 thermistor, 8 microcomputer, 9 capillary, 10 air conditioner, 11 outdoor unit, 12 indoor unit, 13 refrigerant circuit, 31 case, 31a flow inlet portion, 31b flow outlet portion, 32 diaphragm, 33 flow path, 34a valve body, 34b valve seat, 35 spring, 36 partition member, 37 valve hole, 38 small hole, 39 capillary, S1 first chamber, S2 second chamber (pressure reference chamber).

Claims

1. An air conditioner comprising:

a refrigerant circuit comprising a compressor, a condenser, a pressure-regulating valve, and an evaporator; and
refrigerant flowing through the refrigerant circuit in an order of the compressor, the condenser, the pressure-regulating valve, and the evaporator, wherein
the refrigerant is R32,
the pressure-regulating valve comprises
a flow path causing the refrigerant flowing from the condenser to flow to the evaporator,
a pressure reference chamber partitioned from the flow path and filled with inert gas, and
a valve portion disposed in the flow path,
the pressure-regulating valve is configured to adjust a degree of opening of the valve portion to adjust a flow rate of the refrigerant flowing through the flow path, and
the valve portion is configured to increase the degree of opening when a pressure in the flow path is higher than a pressure in the pressure reference chamber, and

reduce the degree of opening when the pressure in the flow path is lower than the pressure in the pressure reference chamber.

2. The air conditioner according to claim 1, wherein an amount of the refrigerant flowing through the refrigerant circuit is 300 g or more and 500 g or less. 5
3. The air conditioner according to claim 1 or 2, wherein the pressure-regulating valve comprises a capillary, and the capillary is disposed between the valve portion and the evaporator in the refrigerant circuit. 10
4. The air conditioner according to claim 1 or 2, wherein the pressure-regulating valve comprises a capillary, and the capillary is disposed in parallel with the valve portion in the refrigerant circuit. 15
5. The air conditioner according to any one of claims 1 to 4, wherein the compressor is configured to variably control a number of rotations. 20

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FIG.1

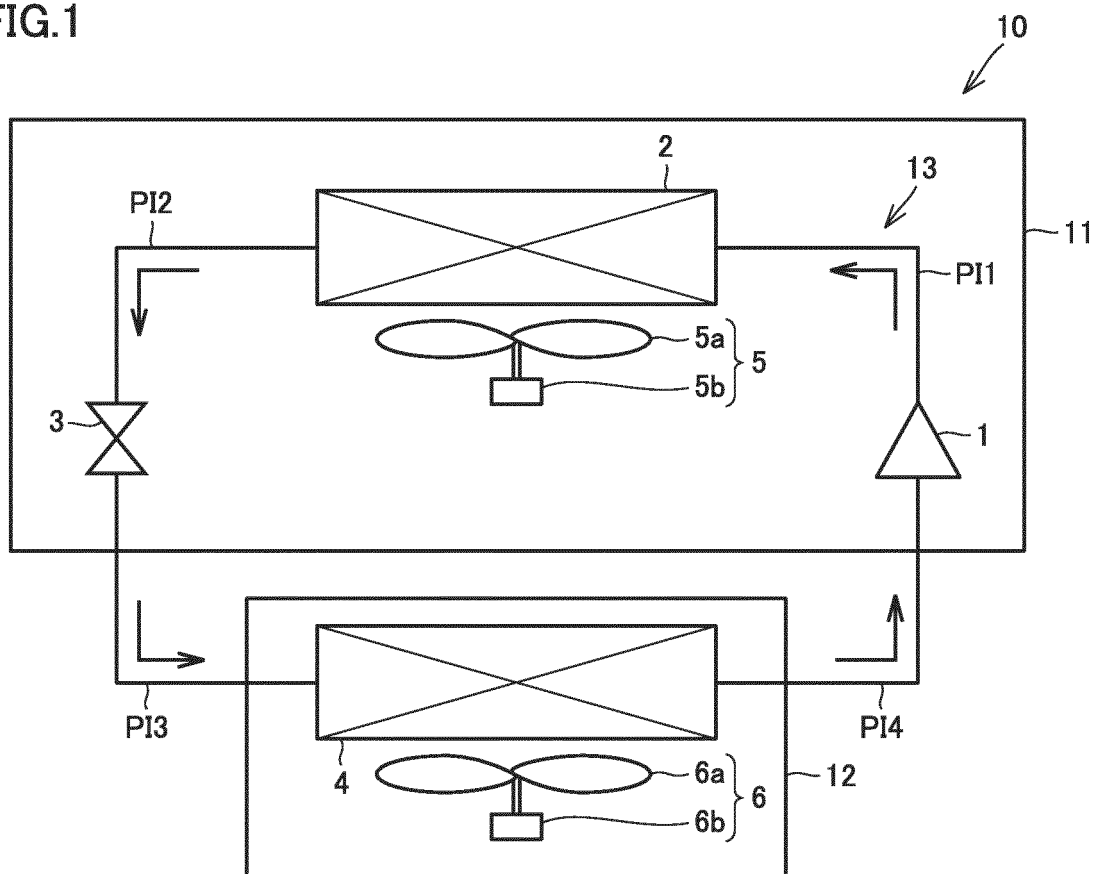


FIG.2

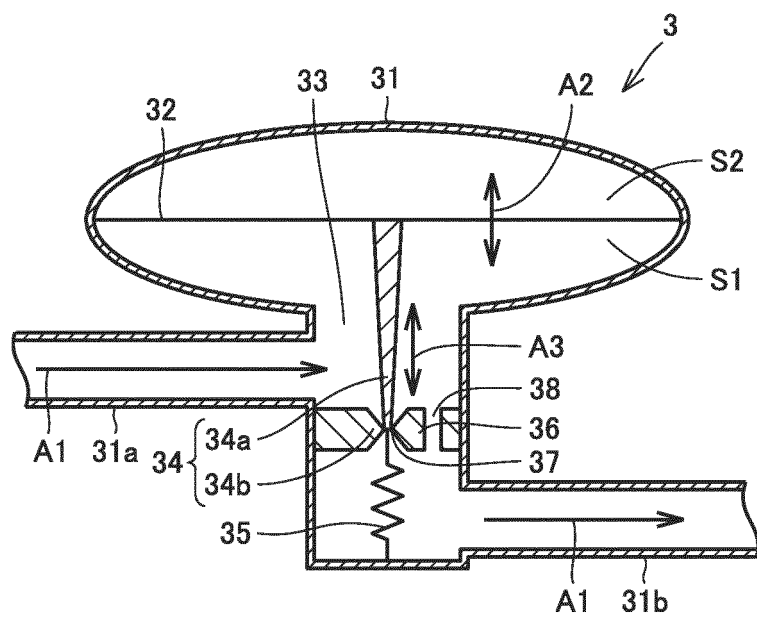


FIG.3

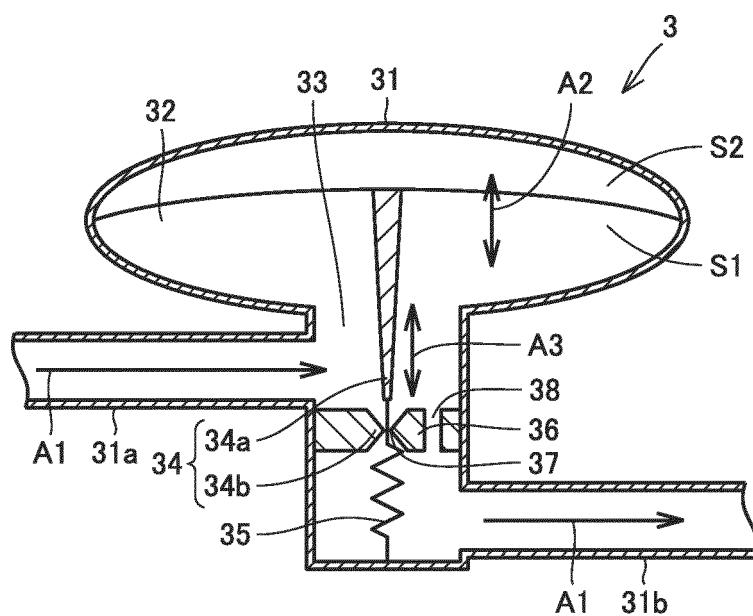


FIG.4

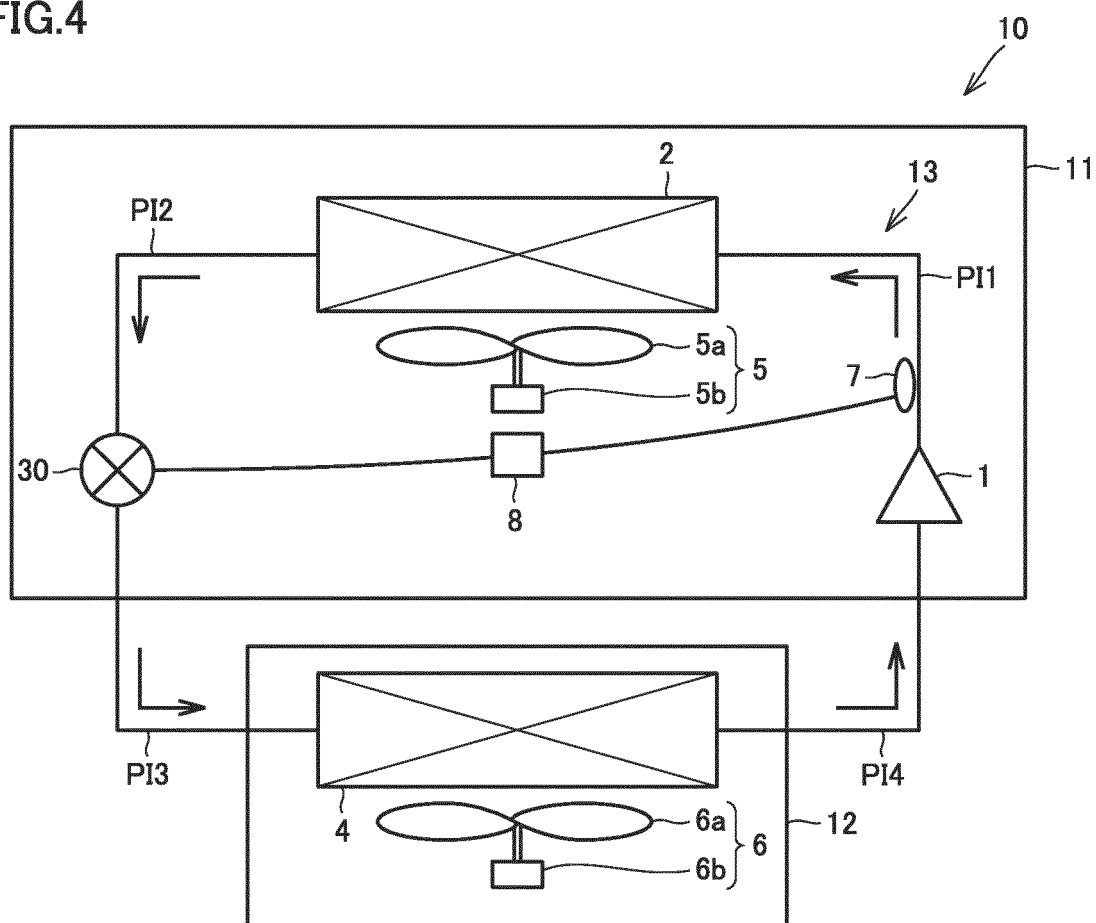


FIG.5

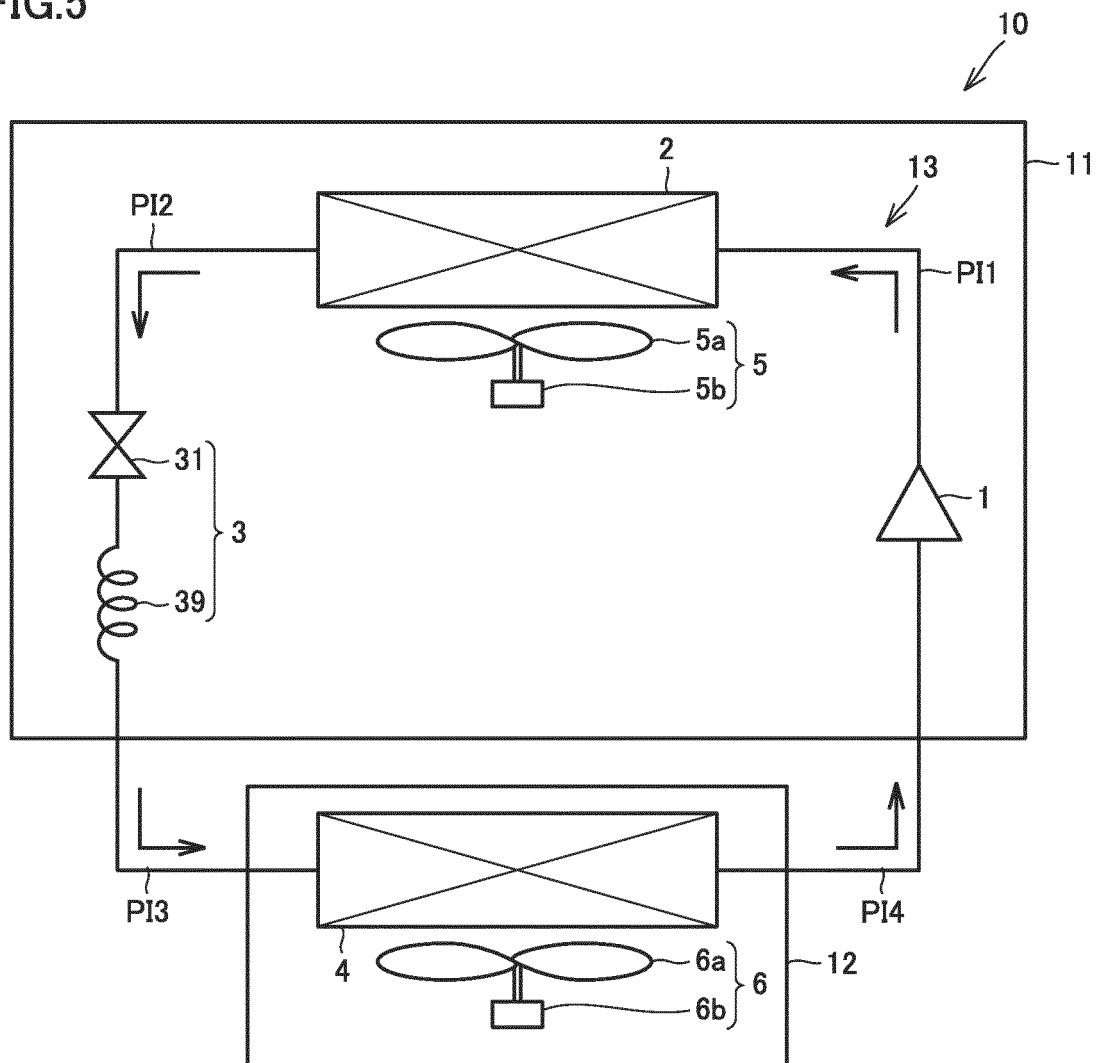


FIG.6

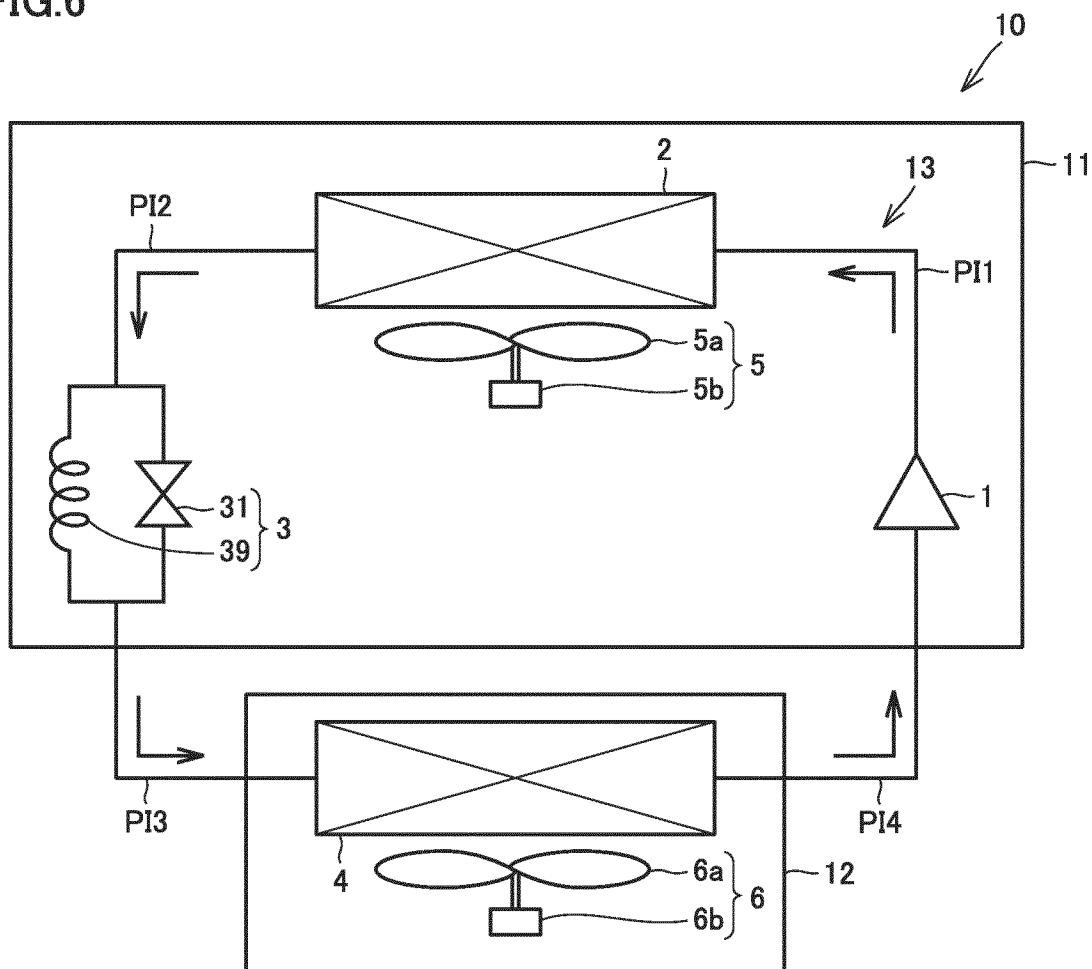
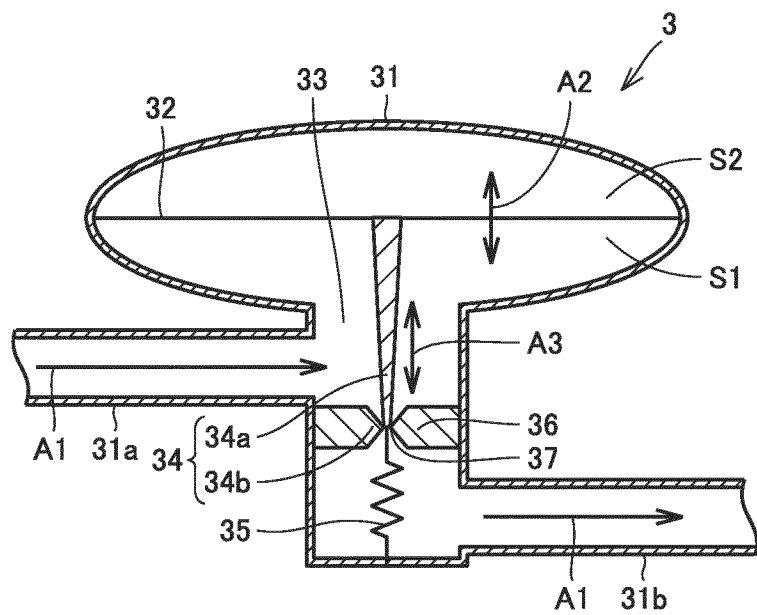


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/082119

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F24F11/02(2006.01)i, F25B41/06(2006.01)i, G05D16/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B1/00, F24F11/02, F25B41/06, G05D16/06

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 08-121879 A (Mitsubishi Heavy Industries, Ltd.), 17 May 1996 (17.05.1996), claims; fig. 1 to 2 (Family: none)	1-5
Y	JP 2007-298271 A (Otto Egelhof GmbH & Co. KG), 15 November 2007 (15.11.2007), claims; fig. 1, 3 & US 2007/0295016 A1 & DE 102006021327 A & FR 2900716 A & CN 101135387 A	1-5
Y	JP 2009-243607 A (Fuji Koki Corp.), 22 October 2009 (22.10.2009), claims; fig. 1 to 4 & US 2009/0242810 A1 & EP 2848878 A2 & CN 101551038 A	1-5

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

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Date of the actual completion of the international search
06 January 2017 (06.01.17)

Date of mailing of the international search report
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Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/082119

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2016-114274 A (Toshiba Carrier Corp.), 23 June 2016 (23.06.2016), claims (Family: none)	1-5
Y	JP 2013-032874 A (Saginomiya Seisakusho, Inc.), 14 February 2013 (14.02.2013), claims & CN 102914104 A	1-5
Y	JP 2015-215127 A (Panasonic Intellectual Property Management Co., Ltd.), 03 December 2015 (03.12.2015), claims 1 to 2 (Family: none)	1-5
Y	JP 2007-198712 A (Sanden Corp.), 09 August 2007 (09.08.2007), claims; fig. 3 to 4 (Family: none)	3, 5
A	JP 09-264622 A (Denso Corp.), 07 October 1997 (07.10.1997), entire text; all drawings & JP 2006-138628 A & US 5890370 A & EP 786632 A2	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016109356 A [0004] [0005]